MODIS Team Member - Semi-annual Report

Marine Optical Characterizations
December 2002

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NOAA/NESDIS

SUMMARY

Since the launch of NASA's MODIS-Terra and MODIS-Aqua satellites, the Marine Optical Characterization Experiment (MOCE) Team has continued to acquire and provide at-sea observations for MODIS initialization and calibration tasks. The Marine Optical Buoy (MOBY) system has been acquiring optical and basic meteorological observations coincident with Terra and Aqua's overpasses in support of the Moderate Resolution Imaging Spectrometer's (MODIS) ocean color mission. During this period, the team conducted seven field campaigns in Hawaii in support of the MOBY project. These cruises, designated MOBY L-82 through MOBY L-87 and Oahu-3, serviced the MOBY220 and MOBY221 systems. An extremely successful field experiment, Turbid-07, was conducted in the Chesapeake Bay aboard the S/V Bay Hydrographer, providing satellite match-ups and missing variable concentration ranges needed for our algorithm development. Additionally, the team is continuing to provide the SeaWiFS Project observations for their validation and long-term calibration tasks and to collaborate with NIST personnel in conducting stray-light characterizations of the MOBY/MOCE optical systems. A summary of the team activities during this reporting period is shown in Figure 1.

FIELD OPERATIONS

The **Oahu-3** field experiment occurred July 8 - July 18, 2002. The team performed daily small boat operations (off the coast of Oahu aboard the R/V Klaus Wyrtki) making optical measurements in support of validating MODIS Terra, MODIS Aqua, and SeaWiFS satellites. Five stations were occupied during this trip with a total of 12 TSM and POC samples collected. Figure 2 shows MICRPRO instrument deployment. The new FOS/ROV upwelling radiance fiber system was tested while on station (Figures 3 and 4). During this trip, preliminary work was also performed in establishing a wireless data communications system at the MOBY operations site.

During **MOBY L-82** (July 24 - 26), MOBY, Meteorological station (LMOB), and CIMEL maintenance was performed. Terrence Houlihan flew to Maui on July 24 and sailed to the Lanai mooring site on July 25 with Hawaiian Rafting Adventure (HRA) Captain Steve Juarez and his mate to clean MOBY 220 sensors and recharge the antifoulants. The Lanai CIMEL instrument was serviced on July 26.

During **MOBY L-83** (August 17- 19), Mark Yarbrough flew to Maui and sailed to the Lanai mooring site with HRA Captain Steve Jarez and his mate to clean MOBY 220 sensors and take underwater photos. The HRA boat broke down on August 19.

MOBY L-84 occurred August 26, 2002. The primary purpose of this trip was to install antifoulant tubes on MOBY sensor windows.

The Turbid-07 field experiment occurred August 24 - September 16, 2002. The following personnel participated in this experiment:

NOAA - Dennis Clark, Ed Fisher, Chris Kinkade, Eric Stengel, Marilyn Yuen-Murphy
QSS/NOAA - Larissa Koval, Mike Ondrusek
DSTI/NOAA - Yong Sung Kim
MLML - Stephanie Flora
MLML/QSS/Hawaii - Mike Feinholz, Mark Yarbrough
MLML/Hawaii - Terry Houlihan

We were able to apply the same small boat technology developed for the R/V Klaus Wyrtki to a similar size boat, the NOAA S/V Bay Hydrographer, in the Chesapeake Bay (Figures 5 and 6). This cruise was unique in that the entire suite of measurements needed to be conducted on a small vessel that had never been used before. This outfitting required several days of fabrication of flow-through runs, instrument platforms and housings, and cabling. The tracking system for the cruise was modified to accommodate the smaller size of the boat. Dennis Clark's home basement in Mill Creek, MD was converted into a wetlab (Figure 7). The S/V Bay Hydrographer was used for daily cruises that departed and returned to Sandy Point harbor, Maryland. A total of 22 stations were occupied with a total of 93 TSM and 127 POC/PC samples collected. 194 fluorometric samples were analyzed at the Mill Creek site, while 120 HPLC samples were sent to CHORS for analysis. Fluorometric chlorophyll *a* values ranged from ~ 15 to over 60 mg m^{-3} , increasing the range of pigment-water leaving radiance match-ups for the MODIS pigment retrieval algorithm. These experiments enabled the bio-optical characterization of "green" water in contrast to the "blue" water we normally encounter in Hawaii.

During the Chesapeake Bay field experiment, we modified, maintained, and operated NOAA's SeaBird SBE-19-03 CTD, which was hand-lowered from the aft A-frame of the R/V Bay Hydrographer. Incorporated with the CTD were: a Wet Labs C-Star Transmissometer (10 cm path, 532 nm LED source), a Wet Labs WETStar Chlorophyll Fluorometer ("coastal" configuration for 0.06 to 150 µg/L Chlorophyll, 470 nm LED excitation, 685 nm emission), a Wet Labs WETStar Colored Dissolved Organic Matter (CDOM), Fluorometer (370 nm LED excitation, 460 nm emission), all plumbed with the CTD conductivity cell via an SBE underwater pump. Calibrations were performed daily for the transmissometer - "dark" and "air" readings - after thoroughly cleaning glass windows, and rechargeable batteries were replaced daily. Data were downloaded and processed via SBE SEASOFT-Win32 software and displayed via MATLAB after each profile for review by the science crew. Post-cruise processing involved analyzing the transmissometer calibration history, incorporating calibration conversions for chlorophyll and CDOM concentrations and creating graphics. See Appendix 3 for SeaBird CTD stations.

The Chesapeake Bay Turbid-07 series of day cruises allowed for the intercomparison between multiple CDOM sensors. The AC9 sample stream was filtered with a 0.2 μ Acropak filter to allow for the determination of CDOM which can then be compared with CDOM measurements made by different investigators on the same water.

During this cruise, the Spectrex PC2000 laser particle counter was used. The high level of particulates in the Bay made it necessary to dilute samples before analyzing them.

The ROV system was delivered and used during the Chesapeake Bay experiment. The long 1.0 mm fibers worked well and we demonstrated our ability to operate this type of system without damaging the fibers. We also demonstrated the ability to achieve stable radiometry using long lengths of fiber optics in the water leading back to a shipboard instrument. The lack of adequate thrust in the ROV is still a problem. The low thrust of the existing ROV limits our ability to control the depth and attitude of the fiber collectors. We are still waiting for the thruster upgrade of the ROV that will hopefully solve this problem.

The weather and bay conditions during this trip gave us an excellent opportunity to continue our study of instrument shadowing effect on water-leaving radiance measurements. The experiments were performed on the pier in the Mill Creek (Figure 8). The experimental setup was based on two American Holographic MD5 dual channel spectrometers. One covered the spectral range of 380 - 710 nm. The other 600 - 900 nm. The spectrometer accepts two fiber optic inputs. One fiber was connected to an irradiance sensor that monitors the incident irradiance. The other fiber, with a 0.22 numerical aperture (18° field of view in water), measures upwelling irradiance (Lu) just below water surface. Disks of different diameter (12, 24, 40, and 56 cm) were then attached to the connector to simulate various instrument sizes. During the experiments, the depth of the disks were adjusted to as close to the surface as possible but enough to avoid any disturbances from capillary waves (Figure 9). In some cases, data were taken at various depths in order to see the effect on the attenuation coefficients. A sequence was followed in the measurements. Data were collected first with bare fiber, then disks of increasing diameters were attached. Incident irradiance was measured at the same time as radiance and then used to take out variations caused by changes in the incident light field. All data were collected in clear sky conditions. These data were processed after the trip and are ready to be analyzed.

The new under-water radiance distribution system (Nurads), developed by Ken Voss at the University of Miami, was utilized during this trip. This instrument worked well and provided a large data set that is being used to characterize the under-water radiance light field in a variety of water types. Two shadowband instruments were also setup during this trip.

MOBY L-85/MOCE-10 occurred October 11 - October 19, 2002. The first part of this trip (MOBY 85) was dedicated to the MOBY ezchange. The R/V Ka'imikai-O-Kanaloa departed Honolulu, Hawaii on the morning of October 11, deployed MOBY221 at the Lanai mooring site on October

12, and recovered MOBY220 on October 13. The second leg of the trip (MOCE-10) was spent steaming around the main Hawaiian Islands to the south of the Big Island (Hawaii) characterizing the marine optical properties relevant to ocean color satellite validation. Inclement weather conditions prevented daily calibration/validation activities; however, four bio-optical data stations were accomplished during this cruise, and HRA Captain Steve Jurez and his mate assisted Mark Yarbrough with initial diver reference scans on MOBY221 (Figure 10). 52 TSM and 67 POC/PC water samples were collected and filtered for analysis. A total of 86 fluorometric and 86 HPLC samples were collected. The fluorometrically derived chlorophyll *a* concentrations have been computed for both tracklines and on stations data sets. The station data were used to determine variability in chlorophyll concentrations during various optical measurements. See Appendix 4 for SeaBird CTD stations.
The following personnel participated in this cruise:

NOAA - Dennis Clark, Ed Fisher, Eric Stengel, Marilyn Yuen-Murphy
MLML - Jill Baltan, Stephanie Flora, Darryl Peters
QSS/NOAA - Larissa Koval, Mike Ondrusek
MLML/QSS/Hawaii - Mike Feinholz, Mark Yarbrough
MLML/Hawaii - Terry Houlihan
DSTI/NOAA - Yong Sung Kim
NOAA/CIRA - Chris Kinkade
University of Miami - Ken Voss
NASA - Katherine Bender, Steve Dacey

MOBY L-86 occurred November 18-19, 2002. Mark Yarbrough and Terry Houlihan flew to Maui on November 18 and sailed to the Lanai Mooring site on November 19 with HRA Captain Steve Juarez and his mates and completed two sets of dirty diver calibrations on MOBY221. They returned November 20, cleaned MOBY221 sensors, completed one clean diver calibration, and serviced the Lanai CIMEL instrument.

MOBY L-87 occurred December 4 - 5 and was dedicated to CIMEL site maintenance. Our personnel flew to Maui on December 4 and sailed to the CIMEL site on December 5 to replace solar panels and a battery.

RADIOMETRIC STANDARDS & RADIOMETERS

Team personnel stationed at the NOAA operations facility at Snug Harbor, Hawaii continued maintenance of our NIST-traceable radiometric standards and performed calibrations of our radiometers. The MLML OL420 and OL425 radiance standard spheres were sent to NIST for post-calibration on their lamps, after which they were re-lamped and re-calibrated at NIST. Lamp #06 in the OL420 had 28.5 hours use since its February 17 2000 pre-calibration by Optronic Laboratories, and was post-calibrated at NIST on August 7 2002. Lamp #07 in the OL420 was pre-calibrated by NIST on August 12 2002, and as of the end of September it had provided 17.2 hours use. The

OL425 Lamp #03 was post-calibrated at NIST on August 8 2002 after 17.2 hours use since its December 19 2001 pre-calibration by Optronic Laboratories. Lamp #04 was pre-calibrated at NIST on August 9 2002 and had not been used by the end of September. The status of these new calibrations was reviewed by M. Feinholz and B.C. Johnson during the NIST-2002-05 work at NIST in August. At the end of September 2002, the following summary of calibration sources can be reported: the F453 FEL irradiance standard had 38.8 hours use since its July 1998 NIST calibration; F454 had 21.5 hours on a February 2001 calibration; F471 had 3.6 hours service since its February 2001 calibration. The NOAA Standard Lamp Monitors (SLMs) were returned to NIST in August 2002 for calibration on SIRCUS to repeat the irradiance characterization. In-band response of the SLM-E870 was determined via SIRCUS (f/70, f/82, f/97, overfill diffuser) which agreed with the January 2000 SIRCUS (f/12.8) results. Studies of E870 were performed via the VisSCF which showed that the anomalous results of 1996 (compared to 2000) were due to under-filling the diffuser. Measurements between 1000 and 1250 nm revealed a 1% maximum out-of-band leak around 1100 nm. This wavelength range had not previously been measured, and these results mean that the SLM-E's must be returned to NIST for further long-wavelength characterization. SLM-L412 and L870 viewed the NPR (1,4 Lamps), and preliminary results agreed within 0.5% at 412 nm, and 0.1% at 870 nm using the January 2000 SIRCUS responses. The SLM-E sensors viewed the NIST FEL-F431 and F432, and preliminary results suggest F431 agreed within 0.2% via the January 2000 SIRCUS response.

Radiometric calibrations during the reporting period included:

1. July 2002 Post-deployment MOBY219 Eu, Es, Ed Top, Ed Mid and Bot, Post-Oahu-3 MOS202cfg08 Lu and Post-MOBY L-80 MOS205cfg07 Lu
2. August 2002 Post-Oahu-3 and Pre-Turbid-07 SIS101cfg04, Post-Oahu-3 MOS202cfg08 Ed and Post-MOBY L-80 MOS205cfg07 Lu
3. October 2002 Pre-deployment MOBY221 and Pre-MOCE-10 SIS101cfg04, Pre-MOCE-10 MOS202cfg09 and Pre-MOCE-10 MOS205cfg08
4. December 2002 Post-deployment MOBY220 and Post-MOCE-10 MOS204cfg06

Detailed listing of calibrations and maintenance for each standard and instrument are provided in Appendix 1.

STRAY LIGHT CHARACTERIZATION

NIST researchers Carol Johnson and Steve Brown returned to Hawaii once during the reporting period to continue stray-light characterization and algorithm development in December 2002 (NIST-2002-06), to characterize the effect of temperature on MOS and to finish up the MOS profiler stray light corrections. A number of Matlab programs were written to find the reflection peaks, in-band scan areas and other variables required to characterize the stray-light. Steve Brown derived the MOS profiler parameters and Stephanie Flora modified the MOS stray-light programs to check the new algorithm.

Another meeting - NIST-2002-05 - occurred in August 2002 in Maryland, during which the work on SLC algorithm development continued. The NIST SIRCUS and Colored Source are now routinely operated in the calibration hut and in the MOBY tent. Additionally, NIST provides several HeNe lasers, diode laser, and an air-cooled Argon-Ion laser for out-of-band responsivity and second order reflection peak modeling measurements. The NIST OL420 Colored Source and Visible Spectroradiometer, VisSR, were operated in conjunction with the MLML OL425 and MOBY Lu sensors to provide an algorithm validation data base. The Stray-Light Correction, SLC, algorithm for the profiling MOS202 was evaluated on MOCE-5 data sets, confirming that the blue/red overlap discrepancy was caused by stray light in both spectrographs. Additional SIS and FOS data were collected: the first FOS SLC algorithm was applied to the FOS data, FOS temperature studies were continued, SIS corrections have begun, and MOS/MOBY saturation studies were performed using various discrete-wavelength laser sources and the broadband OL420 source. Finally, they have been preparing "*Stray Light Correction of the Marine Optical Buoy*" for the SeaWiFS Technical Report Series.

MOCE/MOBY INSTRUMENTATION

FOS

We abandoned our work to integrate the data acquisition of the 4 data streams produced by FOS. Limitations of the Matlab instrument control software among other problems made the new system unstable and cumbersome to use. We continue to use the old acquisition systems without any problems. The use of FOS as a part of the ROV radiometer reduces the need to acquire the ancillary data. We may pursue this in the future with a different instrument control language.

MICROPRO

The MICROPRO processing programs were modified to accommodate the slow descent rates required during the Turbid-7 cruise. Stability of the MICROPRO and MICROREF instruments will continue to be monitored using the Gamma Scientific RS10 lamp system. Satlantic provided new calibration files before the Turbid-7 cruise to replace the last set.

ROV

The ROV system was delivered and used during the Chesapeake Bay Turbid-7 cruise and in Hawaii during the MOCE-10 cruise. The long 1.0 mm fibers worked well and we demonstrated our ability to operate this type of system without damaging the fibers. We also demonstrated the ability to achieve stable radiometry using long lengths of fiber optics in the water leading back to a shipboard instrument. The lack of adequate thrust in the ROV is still a problem. The low thrust of the existing ROV limits our ability to control the depth and attitude of the fiber collectors. We are still waiting for the thruster upgrade of the ROV that will hopefully solve this problem.

MOBY

MOBY refurbishing proceeded as usual without difficulty. Mooring Systems is in process of fabricating replacement collector standoff and clamp components. The prototype replacement was delivered and tested for fit and fabrication quality. The new arms will be deployed during the M222 deployment. Based upon this evaluation, the new sets of standoff assemblies will be finished and delivered when we receive next year funding. We have over the last six months filled in the gaps in our spare parts inventory. These include collector bezels, new upper buoy electronics housings and MOBY controller hard disks. There are currently no long lead-time spare parts requirements pending. New mooring components and spare tethers for the January deployment have been delivered.

MOS

There are currently no pressing maintenance issues with the operational MOS2 instrument. MOS units 1, 4, and 5 are fully functional and receive periodic maintenance consisting of CCD head evacuation and coolant pump service. MOS2-1 is to be modified with MUX controller and firmware for use with the ROV/Fiber optic collection platform.

WEATHER STATION

The second Mooring Weather Station (LMOB202) was installed January 2002 in conjunction with the annual replacement of the mooring buoy. This version of the weather system is similar to the previous system, LMOB201, with the exception of an additional sensor being incorporated into the data stream. The wind, temperature, humidity, and PAR sensors continue to collect and transmit data. The underwater sensor data streams have been somewhat intermittent with the transmissometer, fluorometer and conductivity/temperature probes exhibiting problems at various times. Damage seems to occur during field maintenance of the system, resulting in the inability to gain control of the underwater package. One of the two anemometers was lost sometime during the MOBY220 deployment. The anemometer base was inadequately welded to the upper frame of the mooring tower. All towers will be checked and retrofitted if necessary.

The mechanical and electrical integration of the weather station/mooring buoy which is due for deployment in January 2003 is completed. Maintenance procedures will be tested on this buoy to find the hidden flaw in operations. Work continues in testing the Iridium Satellite telemetry of Met station data. We acquired two "free" field hardened iridium systems for use in developing the telemetry link.

CIMEL SERVICE

The Lanai CIMEL site is back in service after two months down time due to a failing internal battery and solar panels. Aeronet provided a new internal battery and we replaced the weathered solar panel array. This system is starting to show signs of advanced corrosion and is due for re-calibration.

The Coconut Island site has worked well for the past 6 months. The instrument received regular monthly service by personnel located at HIMB. This system is also due for re-calibation.

DATA PROCESSING

MODIS CALIBRATION AND VALIDATION

The MODIS-Terra processing code is now considered validated and all the Terra data from the launch to present have been reprocessed by NASA using the new code. The MODIS Aqua satellite was successfully launched in May 2002 and started collecting data towards the end of June. The calibration and validation for the Aqua data processing is still in an early stage. Bob Evans' team at the University of Miami is comparing concurrent daily normalized water-leaving radiance measurements from MOBY and the Aqua Satellite for calibration purposes and the Terra Satellite for continued validations. Most of our effort this reporting period has involved processing match-ups of the two MODIS ocean color satellites to our shipboard measurements. During this period we have extracted Terra to ship comparisons from our May 2002 cruise in Hawaii and ended up with eight clear-sky match-ups. During our July cruise in Hawaii, we had two perfect days where we were able to collect clear-sky radiance data corresponding to the Aqua, Terra, and SeaWiFS satellites. During our August cruise in the Chesapeake Bay, we were able to fully characterize water-leaving radiance for green water with high chlorophyll concentrations however direct overpass comparisons have been difficult due to the close proximity to land. The overpass match-up timing during MOCE 10 was impeded since most days we did not have good satellite viewing angles at our work location or it was cloudy. We did manage two days of Aqua overpass match-ups.

MOBY/MOS/SIS

MOBY now acquires three files a day, coincident with the SeaWiFS and the two MODIS overpasses. MOBY acquisition times are 20:40 (Aqua), 22:47 (SeaWiFS), and 00:10 (Terra) GMT. MOBY only transmits two files (MODIS Aqua and Terra) each day. The SeaWiFS files are downloaded at the end of the deployment and processed. MLML personnel process the files the following day. All files are weighted to MODIS and SeaWiFS bands.

Old MOBY deployments 4, 6, and 8 were reprocessed. Nearly half of MOBY deployment 3 has been reprocessed. The other half will be finished later.

MOS/SIS

Mike Feinholz continues to process data from instrument calibrations and from shipboard MOS and SIS profiles using MATLAB-based MLDBASE system software developed at MLML. Six MOS/SIS optica;l profiles were performed during Oahu-3 in July 2002. Profiles are typically coincident with MOBY profiles and/or SeaWiFS and MODIS -Aqua and -Terra observations. MOS water-leaving radiances are convolved with SeaWiFS and MODIS spectral band responses for integration with our bio-optical data base (see Appendix 2 for a MOS station summary). Software refinement continued for our new PC laptop data acquisition and control system for the MOS and SIS instruments. This has now replaced the aging VAX system for laboratory calibration and shipboard experiments.

MICROPRO

MICROPRO data collected during Turbid-7 experiment have been processed.

MOBY CONTRACTS

The Hawaiian Rafting Adventures contract was given a no-cost extension through April 2003. The current burn rate of the existing contract made it possible to just extend rather than submit a new contract.

MEETINGS

Dennis K Clark attended a MODIS Team meeting in July 22 - 24, 2002. He gave a presentation titled "MODIS Data Product Status" (Appendix 5).

Dennis K Clark attended the EOS-IWG meeting in November 18 - 20, 2002. He gave a presentation titled "Climate Quality Ocean Color Time Series. MOBY Vicarious Calibrations" (Appendix 6).

MOCE Team Activ e

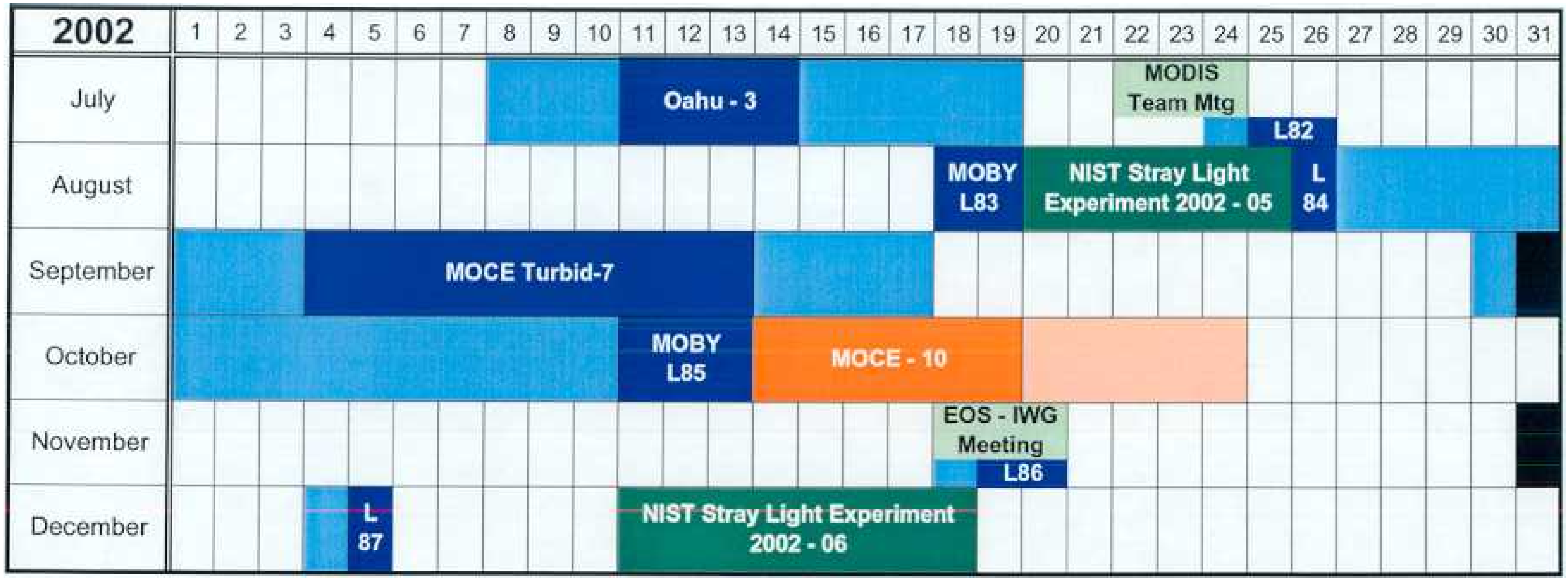

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Fig. 2

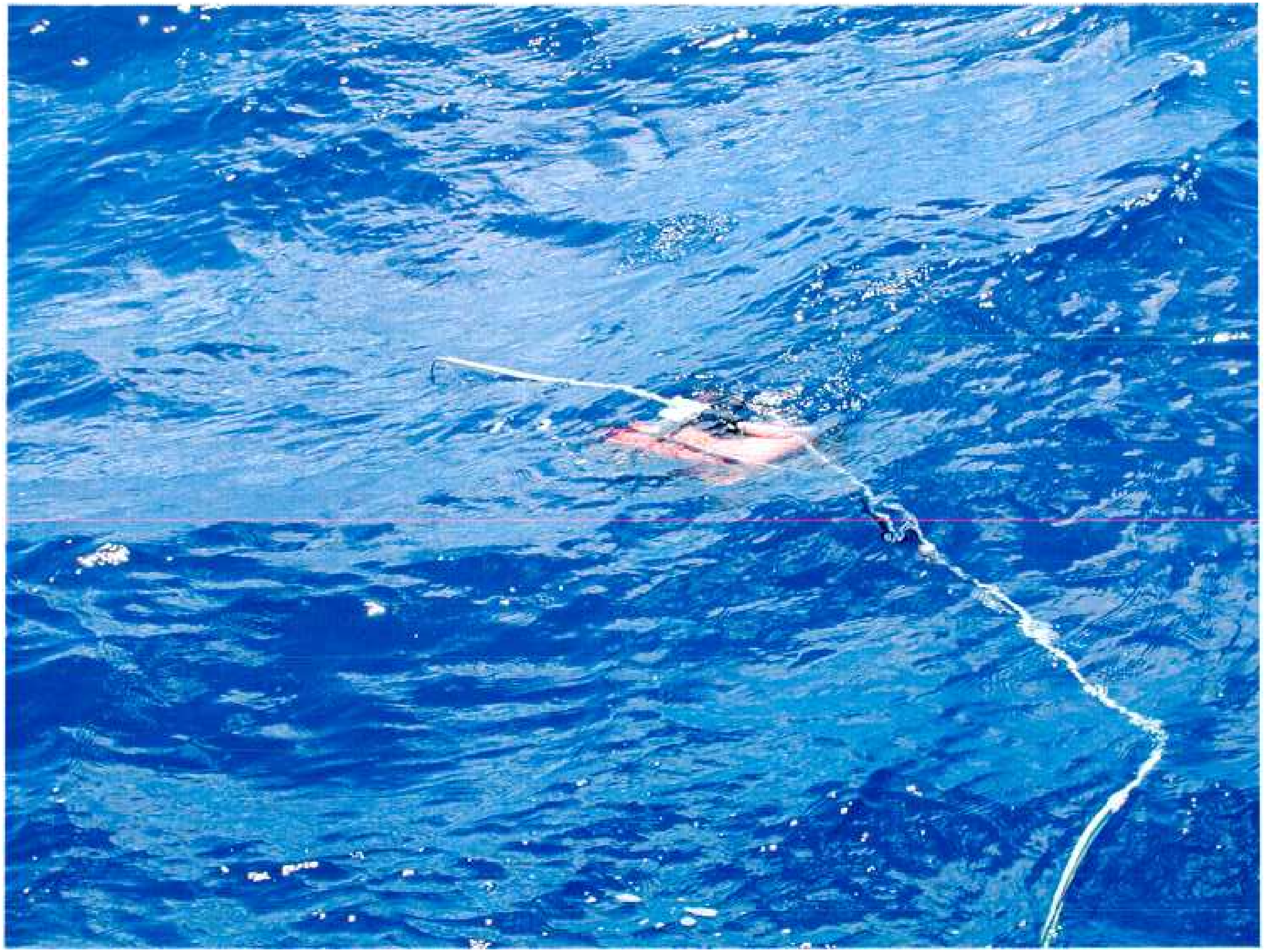


Fig. 3

Fig. 4

Fig 5

Fig 6

Fig. 7

Fig. 8

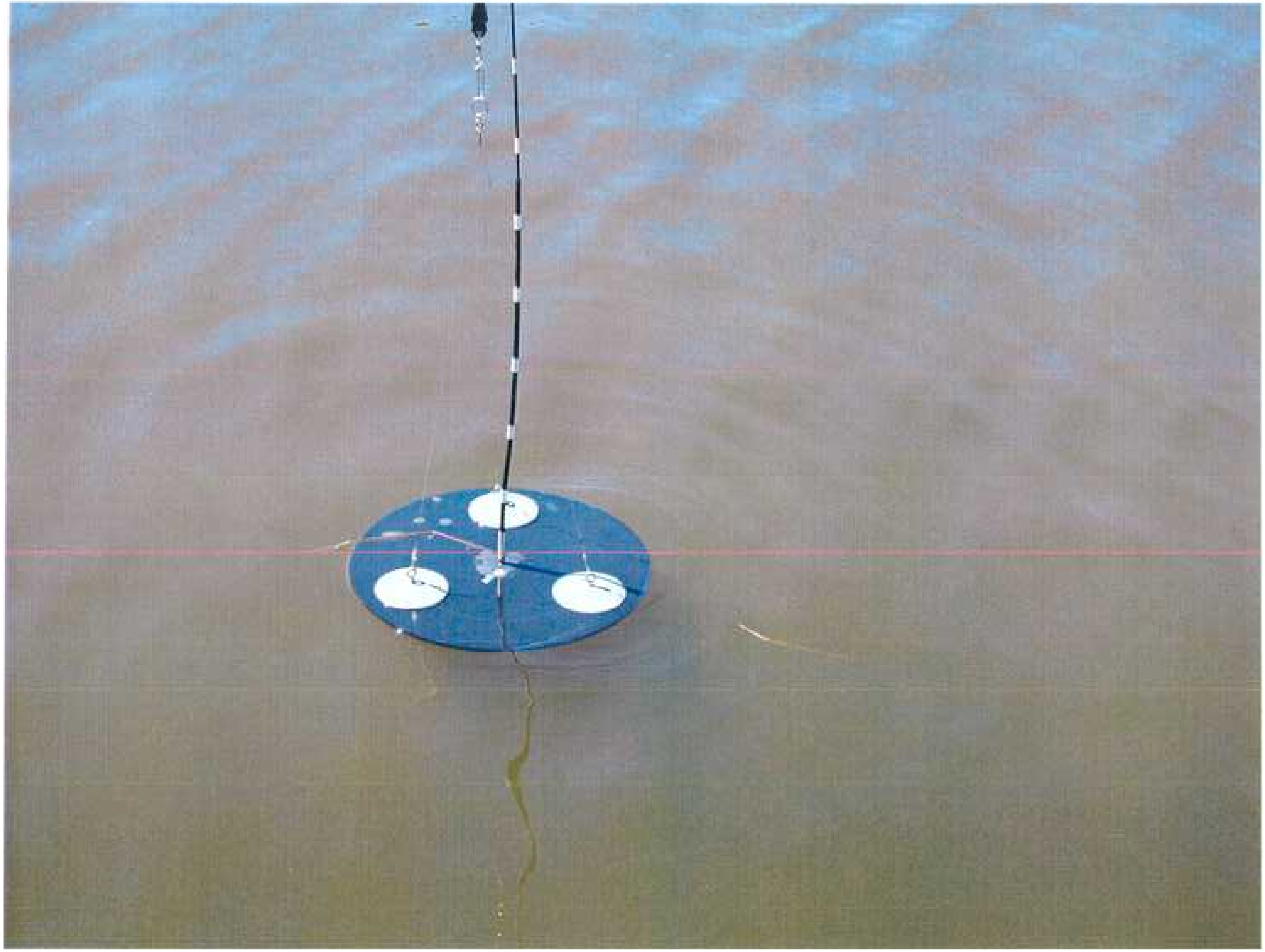


Fig 9

Fig 10

Appendix 1: Turbid-07 SeaBird CTD Stations

Station	Position	Date (GMT)	Filename	Max. Depth
01, Sandy Point I	39° 02.65'N 76° 23.33'W	15:50 (GMT) 04 Sep 2002	02090402.hex	
02, Sandy Pt. II	39° 02.53'N 76° 23.31'W	13:49 (GMT) 05 Sep 2002	02090501.hex	
03, Love Pt. I	39° 01.64'N 76° 20.53'W	16:31 (GMT) 05 Sep 2002	02090504.hex	
04, Podickery Pt. I	39° 02.59'N 76° 23.36'W	13:44 (GMT) 06 Sep 2002	02090601.hex	
05, Harpoon Bay I	38° 58.81'N 76° 24.20'W	16:38 (GMT) 06 Sep 2002	02090604.hex	
06, Belvidere Shoal I	39° 06.97'N 76° 20.04'W	14:06 (GMT) 07 Sep 2002	02090701.hex	
07, Love Pt. II	39° 01.68'N 76° 20.05'W	16:12 (GMT) 07 Sep 2002	02090704.hex	
08, Podickery Pt. II	39° 02.61'N 76° 23.35'W	18:12 (GMT) 07 Sep 2002	02090707.hex	
09, Love Pt. III	39° 01.71'N 76° 20.50'W	13:15 (GMT) 08 Sep 2002	02090801.hex	
10, Belvidere Sh. II	39° 06.95'N 76° 20.01'W	16:54 (GMT) 08 Sep 2002	02090804.hex	
11, Podickery Pt. III	39° 02.59'N 76° 23.30'W	18:43 (GMT) 08 Sep 2002	02090807.hex	
12, Love Pt. IV	39° 01.70'N 76° 20.58'W	13:19 (GMT) 10 Sep 2002	02091001.hex	
13, Pocickery Pt. IV	39° 02.57'N 76° 23.30'W	18:46 (GMT) 10 Sep 2002	02091004.hex	
14, Harpoon Bay II	38° 58.87'N 76° 24.08'W	13:02 (GMT) 11 Sep 2002	02091101.hex	
15, Tolly Pt.	38° 55.51'N 76° 26.27'W	15:15 (GMT) 11 Sep 2002	02091104.hex	
16, Sandy Pt. III	39° 00.38'N 76° 23.28'W	17:21 (GMT) 11 Sep 2002	02091107.hex	
17, Belvidere Sh. III	39° 06.94'N 76° 20.04'W	13:43 (GMT) 12 Sep 2002	02091201.hex	
18, Love Pt. V	39° 01.78'N 76° 20.51'W	15:38 (GMT) 12 Sep 2002	02091205.hex	
19, Podickery Pt. V	39° 02.65'N 76° 23.35'W	17:20 (GMT) 12 Sep 2002	02091208.hex	
20, Love Pt. VI	39° 01.76'N 76° 20.52'W	13:10 (GMT) 13 Sep 2002	02091301.hex	
21, Belvidere Sh. IV	39° 07.02'N 76° 20.03'W	15:10 (GMT) 13 Sep 2002	02091304.hex	
22, Podickery Pt. VI	39° 02.70'N 76° 23.36'W	16:39 (GMT) 13 Sep 2002	02091307.hex	

Appendix 2: MOCE-10 Seabird CTD Stations

Station	Position	Time (GMT) Date	Filename	Max. Depth
01, South East of Big Island	18° 38.96'N 154° 26.47'W	21:02 (GMT) 15 Oct 2002	sbe0153p.mld	195
02, South Point	19° 30.89'N 156° 09.40'W	19:57 (GMT) 16 Oct 2002	sbe0154p.mld	205
03, Craigs Settling Exp	19° 28.93'N 156° 08.60'W	04:22 (GMT) 17 Oct 2002	sbe0155p.mld	501
03, MOBY Mooring	20° 49.60'N 157° 12.65'W	22:40 (GMT) 18 Oct 2002	sbe0156p.mld	207
04, Honolulu	20° 03.51'N 157° 53.63'W	20:13 (GMT) 19 Oct 2002	sbe0157p.mld	207

Appendix 3: Calibrations and maintenance schedules for MLML standards and instruments

• SLM

03-Jul-2002	Post-L80	GS5000-F454 after MOBY219 Eu,EdB,M,T,S
13-Aug-2002	Post-Oahu03	GS5000-F453 after SIS101c04
14-Aug-2002	Pre-Turbid07	GS-RS10/RS1 after SIS101c04
02-Oct-2002	Pre-MOCE10	OL425-W6D100 after MOS205c08
02-Oct-2002	Pre-MOCE10	OL420-W5D100 after MOS205c08
04-Oct-2002	Pre-MOCE10	OL425-W6D100 after MOS202c09
04-Oct-2002	Pre-MOCE10	GS5000-F453 after MOS202c09, SIS101c04
06-Oct-2002	Pre-MOCE10	OL425-W6D100 after MOBY221 LuB,M,T
08-Oct-2002	Pre-MOCE10	GS5000-F471 after MOBY221 Eu,EdB,M,T,S
10-Oct-2002	Pre-MOCE10	OL420-W5D100 after MD512/L.Koval
04-Dec-2002	Post-MOCE10	OL425-W6D100 after MOBY220 LuB,M,T
05-Dec-2002	Post-MOCE10	GS5000-F471 after MOBY220 EuEdB
06-Dec-2002	Post-MOCE10	GS5000-F471 after MOBY220 EdM,T,S
10-Dec-2002	Post-MOCE10	OL425-W6D100 after MOS204c06

• SIS101

13-Aug-2002	Post-Oahu03	GS5000-F453, Es cfg04
14-Aug-2002	Post-Oahu03	HgA, Ne, Es cfg04
14-Aug-2002	Pre-Turbid07	GS-RS10/RS1 1X/10X gain, Es cfg04
27-Aug-2002	Pre-Turbid07	GS-RS10/RS1 1X/10X gain, Es cfg04
28-Aug-2002	Pre-Turbid07	GS-RS10/RS1 1X/10X gain, Es cfg04
29-Aug-2002	Pre-Turbid07	GS-RS10/RS1 1X/10X gain, Es cfg04
14-Sep-2002	Post-Turbid07	GS-RS10/RS1 1X/10X gain, Es cfg04
04-Oct-2002	Pre-MOCE10	GS5000-F453, HgA, Ne via Es cfg04

• MOS202

30-Jul-2002	Post-Oahu03	OL425-W6D100, UP Lu cfg08
01-Aug-2002	Post-Oahu03	GS5-F453, HgA, Ne, DN Ed cfg08
04-Oct-2002	Pre-MOCE10	OL425-W6D100 via UP Lu cfg09
04-Oct-2002	Pre-MOCE10	GS5000-F453, HgA, Ne via UP Lu cfg09
10-Oct-2002	Pre-MOCE10	OL420-W*D100 IntTime via UP Lu cfg09

• MOS204

10-Dec-2002	Post-MOCE10	OL425-W6D100, HgA, Ne via UP Lu cfg06

• MOS205

30-Jul-2002	Post-L80	OL425-W6D100, UP Lu cfg07
02-Aug-2002	Post-L80	HgA, Ne, UP Lu cfg07
02-Oct-2002	Pre-MOCE10	OL425-W6D100, HgA, Ne via UP Lu cfg08
02-Oct-2002	Pre-MOCE10	OL420-W5D100 via UP Lu cfg08

Appendix 3: (continued)

• MOBY219

03-Jul-2002 Post-L80 GS5000-F454, LuB,M,T

• MOBY220

04-Dec-2002	Post-MOCE10	OL425-W6D100 via LuB,M,T
05-Dec-2002	Post-MOCE10	GS5000-F471 via Eu,EdB
06-Dec-2002	Post-MOCE10	GS5000-F471 via EdM,T,S

• MOBY221

06-Oct-2002	Pre-MOCE10	OL425-W6D100 via LuB,M,T
08-Oct-2002	Pre-MOCE10	GS5000-F471 via Eu,EdB,M,T,S

<u>Appendix 4:</u> History of NOAA/MLML Marine Optical System (MOS) Observations.

Cruise: MOCE-10, Ship: R/V Ka'imika-O-Kanaloa, Location: Hawaii (MOS202cfg09)

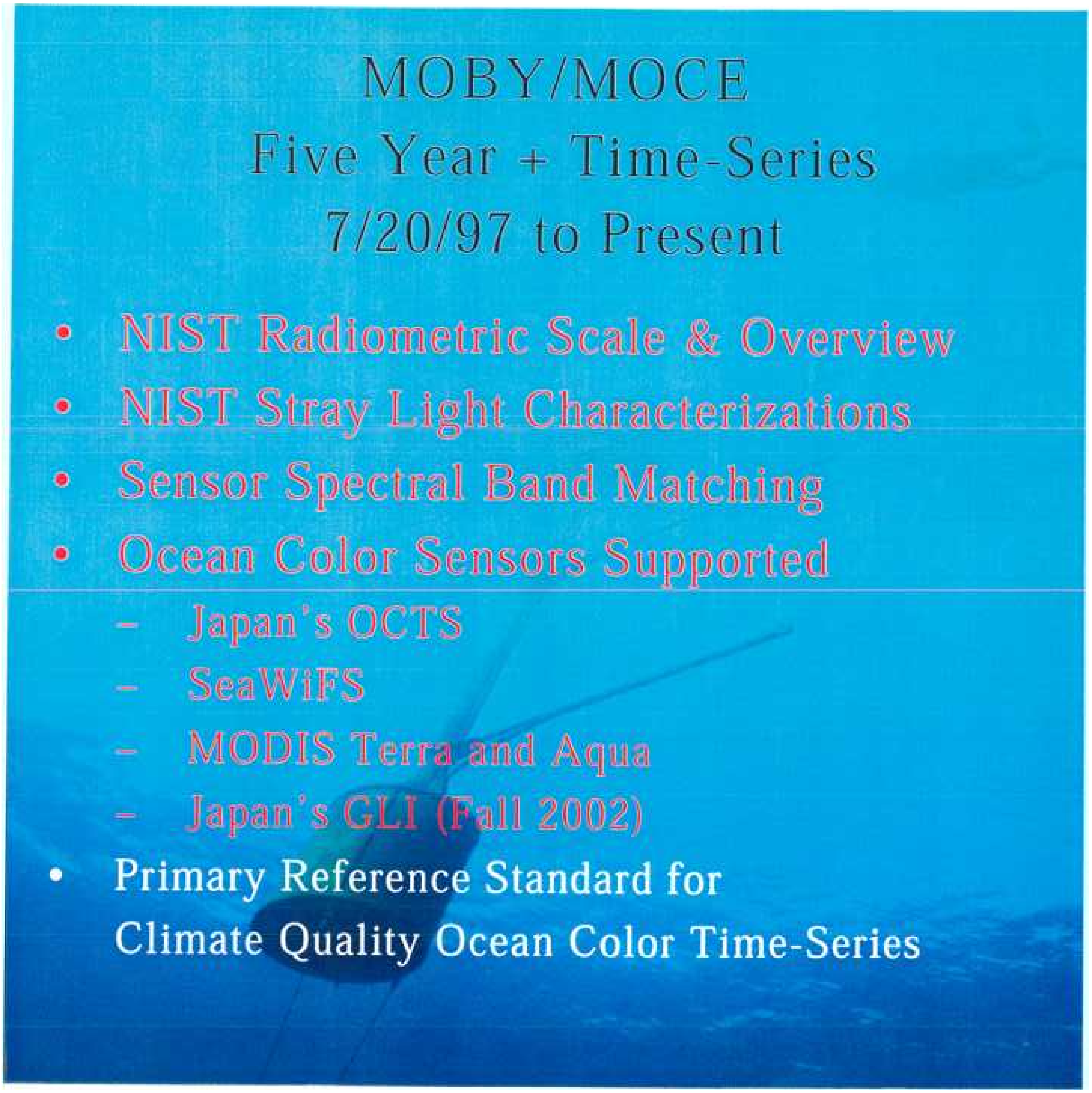
Station (#	Name)	Date (GMT)	Time (GMT)	Latitude (+North)	Longitude (+East)	Depths (dbar)
01	South East of Big Island	15-Oct-2002	22:55	18.651	-154.414	NO MOS
02a	Kailua Kona	16-Oct-2002	23:13	19.540	-156.137	1,5,9,11
02b	Kailua Kona	17-Oct-2002	00:19	19.540	-156.137	1
03a	MOBY Mooring	19-Oct-2002	00:13	20.815	-157.200	1,5,9,11
03b	MOBY Mooring	19-Oct-2002	01:21	20.815	-157.200	1
04a	South of Honolulu	19-Oct-2002	21:36	21.059	-157.896	1,5,9
04b	South of Honolulu	19-Oct-2002	23:56	21.075	-157.969	1,5,9

APPENDIX 5

MODIS Data Product Status
Numbers 19 23 & 26

Denn s K C ark

Ju y 2002


MOBY/MOCE
Five Year + Time-Series
7/20/97 to Present
• NIST Radiometric Scale & Overview
• NIST Stray Light Characterizations
• Sensor Spectral Band Matching
• Ocean Color Sensors Supported
– Japan's OCTS
– SeaWiFS
– MODIS Terra and Aqua
– Japan's GLI (Fall 2002)
• Primary Reference Standard for
Climate Quality Ocean Color Time-Series

MODIS Terra/Aqua Products

Produ 9

n l C m

C y

P MODI

(C y l C C

yl i e HPLC

P l l o

Ch A o y n H C

Produ

m l T l M

D y h

Produ 6 Pa ame er K 490

W F Downwe ad nc D u e Att nu t on

Co nt

nLw calibrations stabilized Produc Impacts

Prob em Ch or mod > To a p gmen concen ra on

n r g on w h h gh pigmen conc n r ion

A h gh a ud

R a on nLw 443 b9 r r eva oo ow and 490 wa ab z ng he 3 band o a p gmen re r eva

Prob m MOD S nLw ca ed o MOBY s ray gh correc ed nLw were re urn ng h gher p gmen concen ra on n he ow concen ra on reg on

- Reason The n wa er rad ome r c mea uremen were no ray gh correc ed

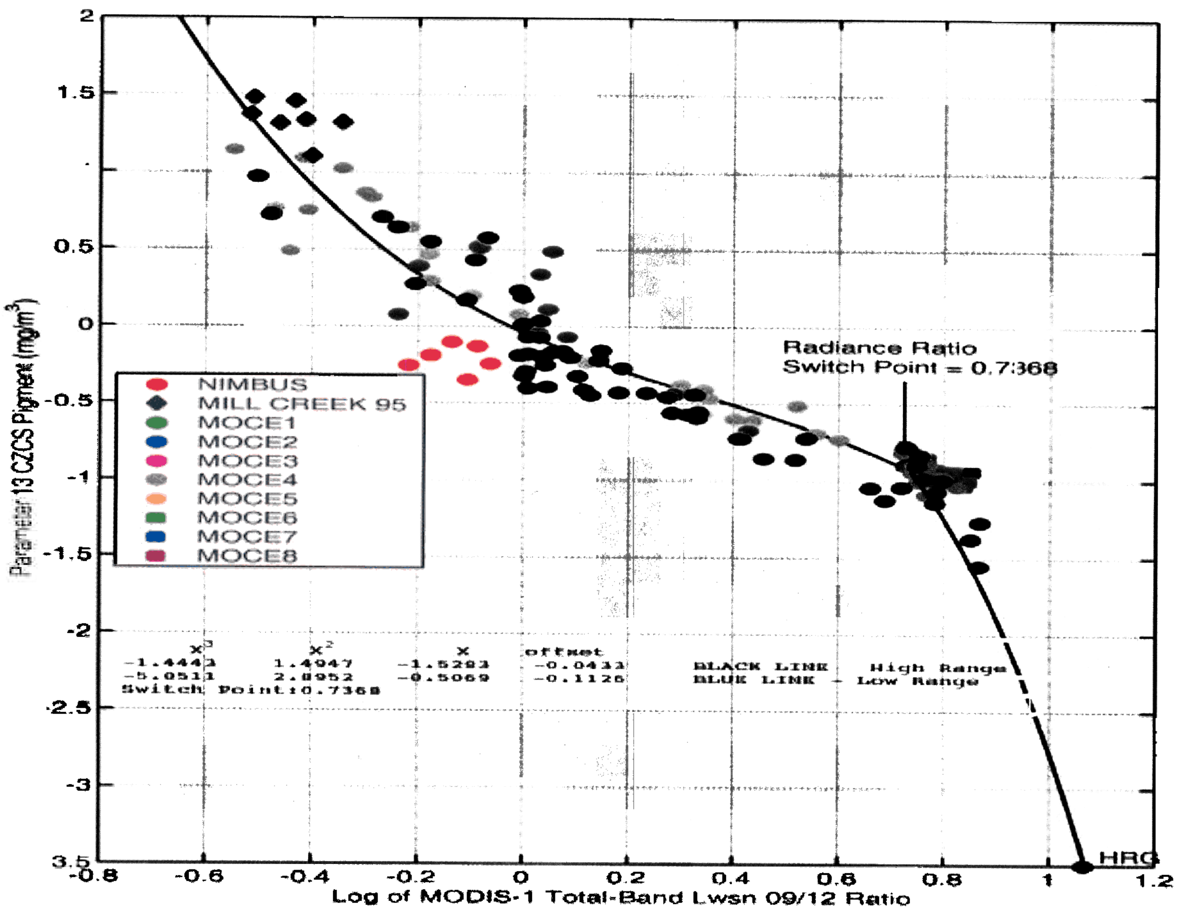
Parameter Modifications

Parame er: 4 & 9 reforn u a ed from 2 band o 3 band ra o h or. MOD & Tot u p nd d Matt

A produc forced hrough Gordon rad ance ra o for pure wa er

In s u b ue wa er nLw were correc ed for ray gh w h he NIST nom na charac e za ons

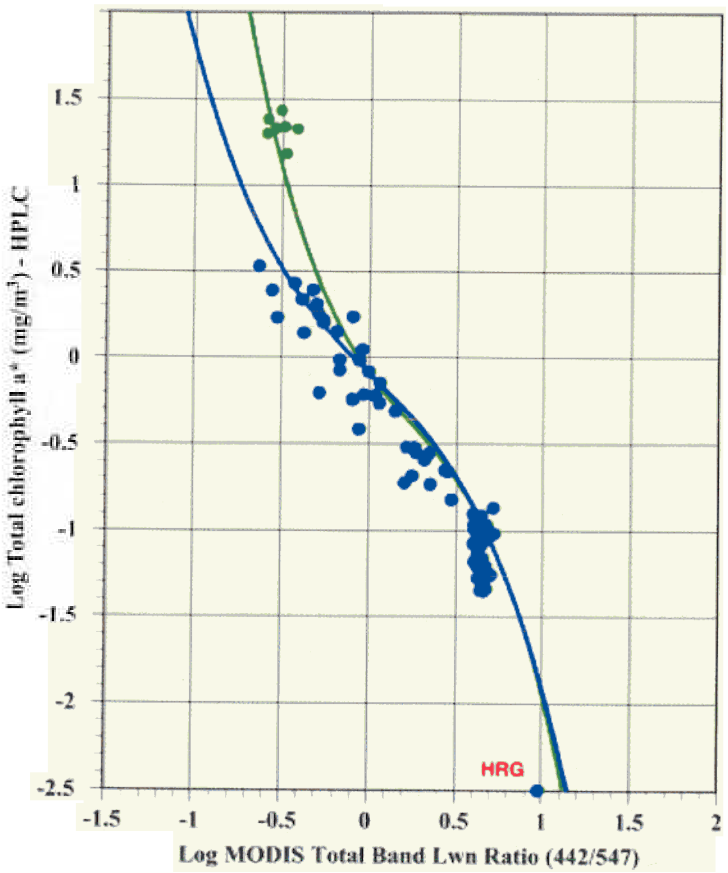
A parame er a gor hm were sp n o wo 3rd order po ynom a o op m ze he h gh rad ance ra o range



Radiance Ratio
Switch Point = 0.7368
NIMBUS
MILL CREEK 95
MOCE1
MOCE2
MOCE3
MOCE4
MOCE5
MOCE6
MOCE7
MOCE8
x^3 x^2 x offset
-1.4443 1.4947 -1.5283 -0.0433
-5.0511 2.8952 -0.5069 -0.1126
Switch Point:0.7368
BLACK LINE High Range
BLUE LINE - Low Range
HRG
Parameter 13 CZCS Pigment (mg/m^3)
Log of MODIS-1 Total-Band Lwsn 09/12 Ratio

Effect of stray light correction on the chl_MODIS Product

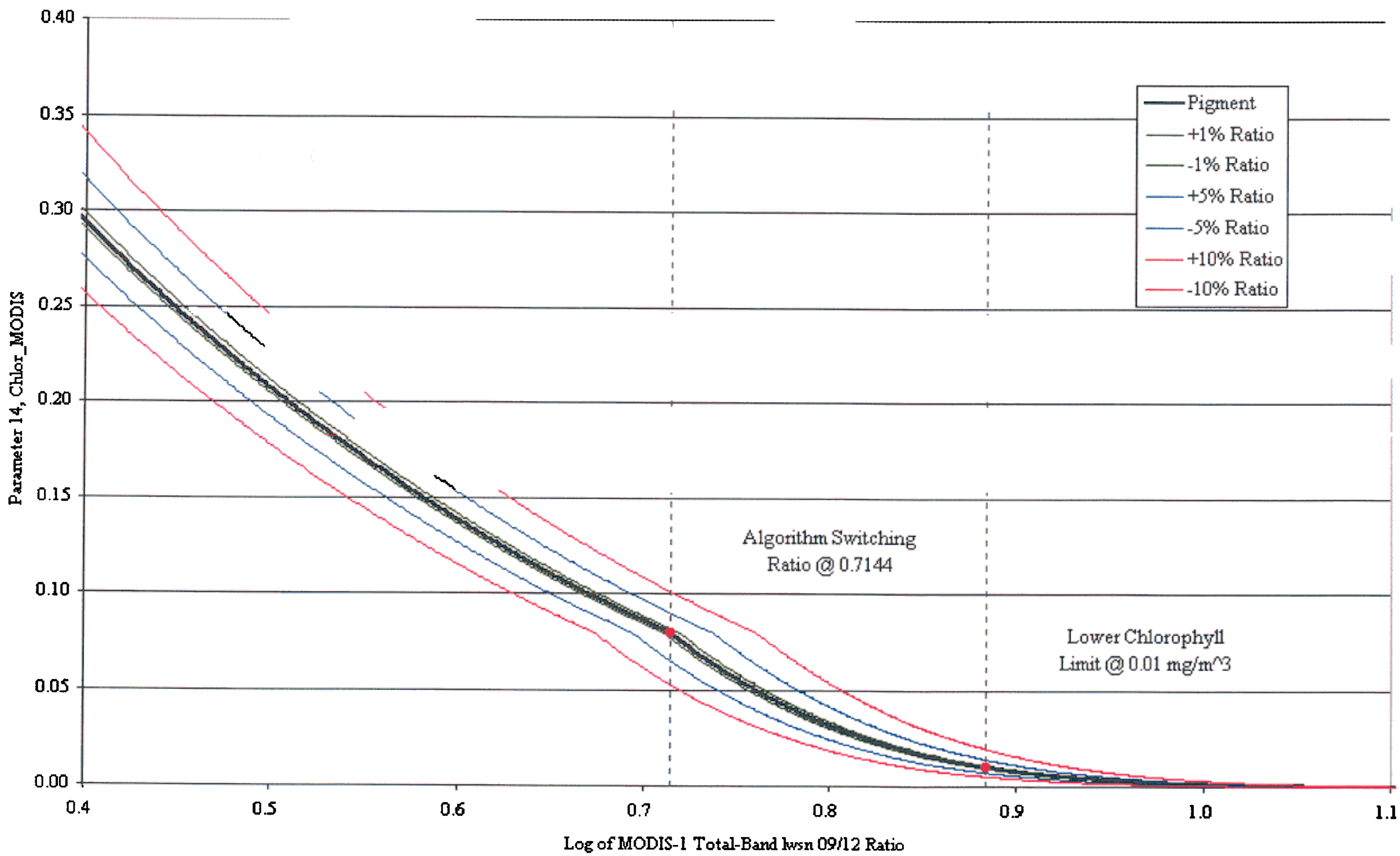
December 2001

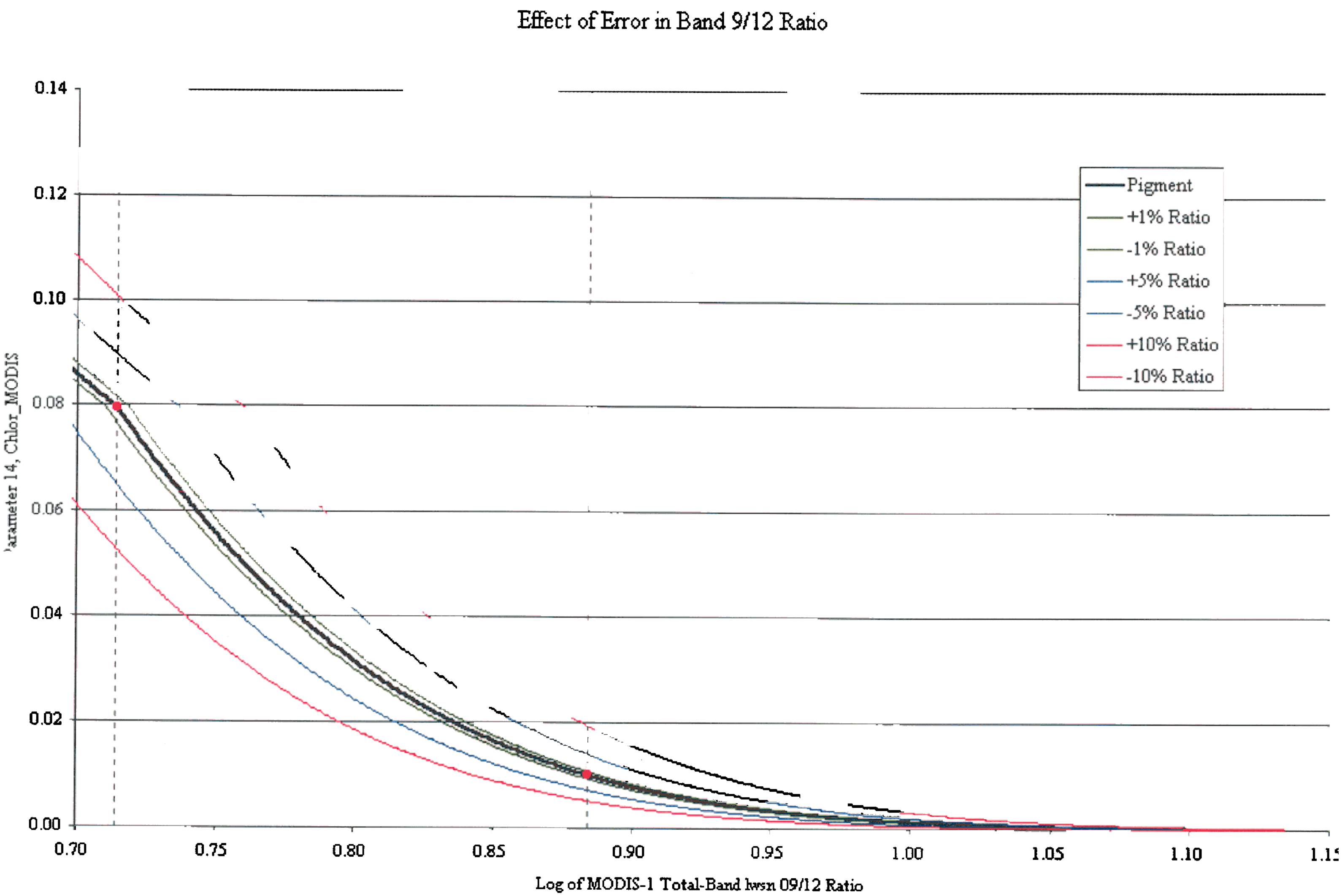


July 2002

QuickTime™ and a
Photo - JPEG decompressor
are needed to see this picture.

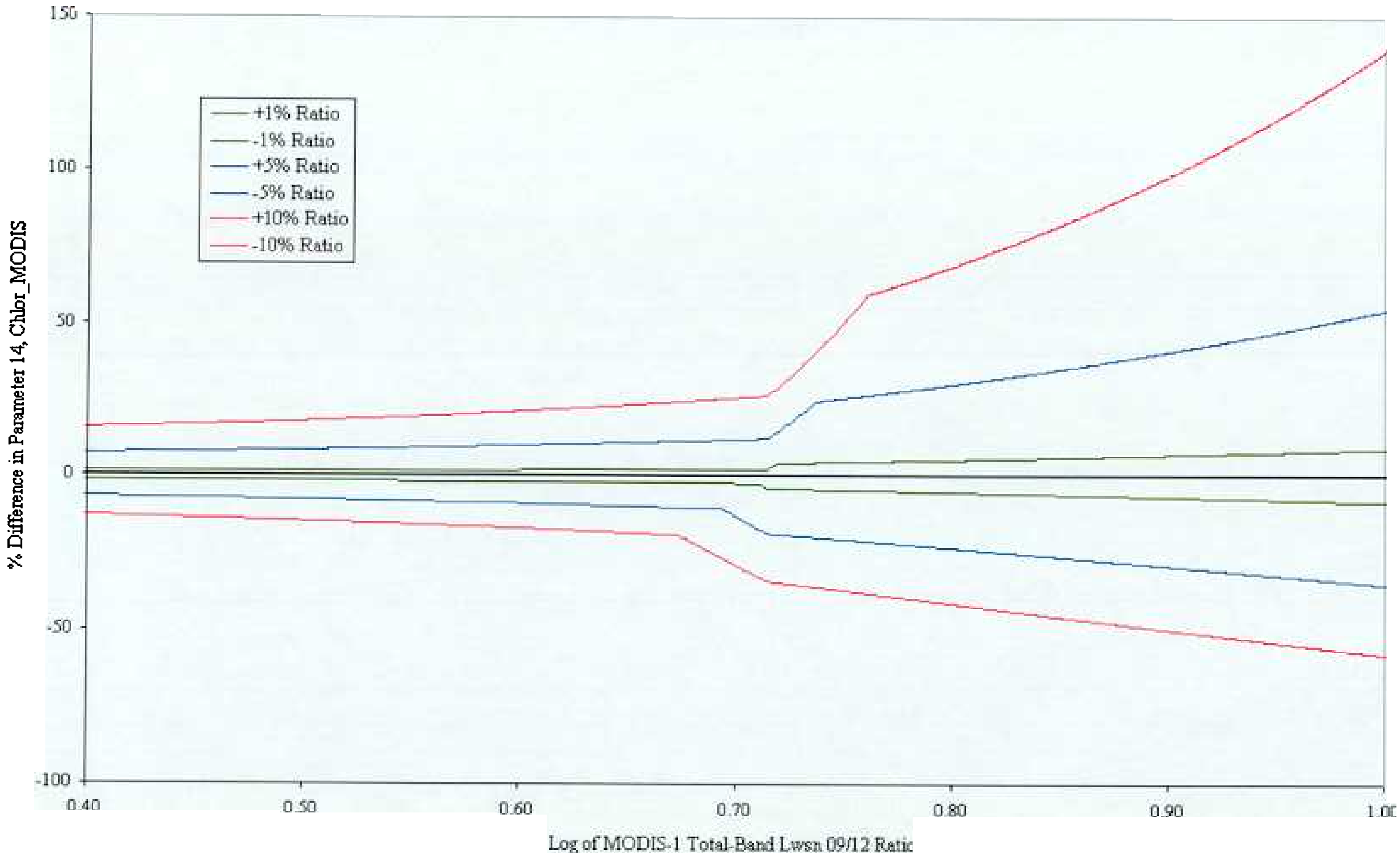
Effect of Error in Band 9/12 Ratio





Effect of Error in Band 9/12 Ratio
Parameter 14, Chlor_MODIS
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0.70
0.75
0.80
0.85
0.90
0.95
1.00
1.05
1.10
Log of MODIS-1 Total-Band lwsn 09/12 Ratio
Pigment
+1% Ratio
-1% Ratio
+5% Ratio
-5% Ratio
+10% Ratio
-10% Ratio

Effect of Error in the Band 09/12 Ratio



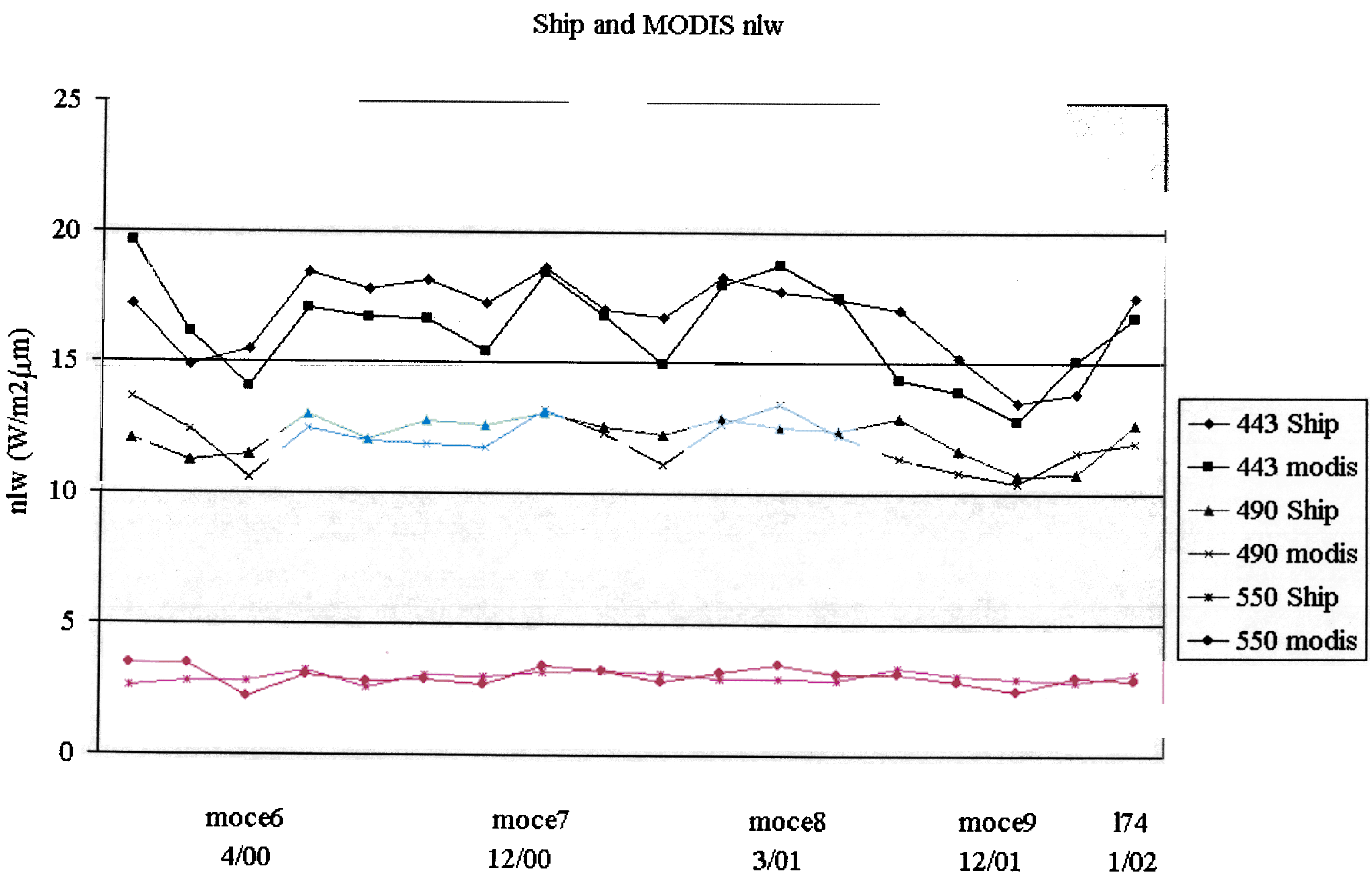
Generalized Form for Product Computation

HIGH Lwn Ratio Range Log Product = (A(Log X) ^3 + B(Log X)^2 + C(Log X) + D) / E
LOW Lwn Ratio Range Log Product = (A(Log X) ^3 + B(Log X)^2 + C(Log X) + D) / E

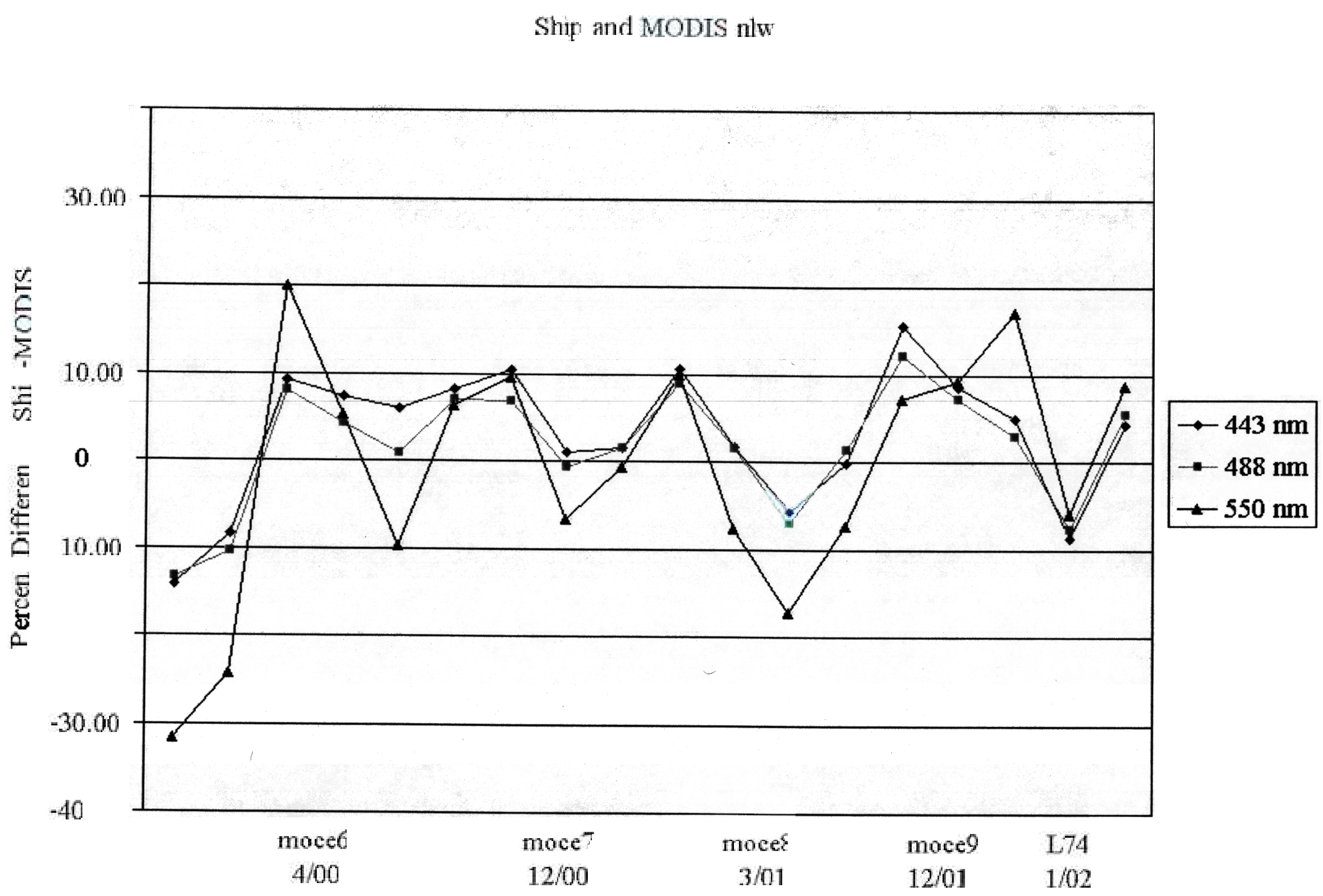
Switch Point (SP) is the value of the log Lwn ratio where :
the HIGH range form is replaced with the LOW range form

- Products 19 and 23
  - Two Least Squares Regressions (Log, Log)
  - 3rd order polynomials
  - $R^2 > 0.91$; $S_{yx} \sim .045$
- Product 26
  - Least Squares Regression
  - Linear
  - $R^2 = 0.94$; $S_{yx} = 0.167$

Initial MOCE Va idations

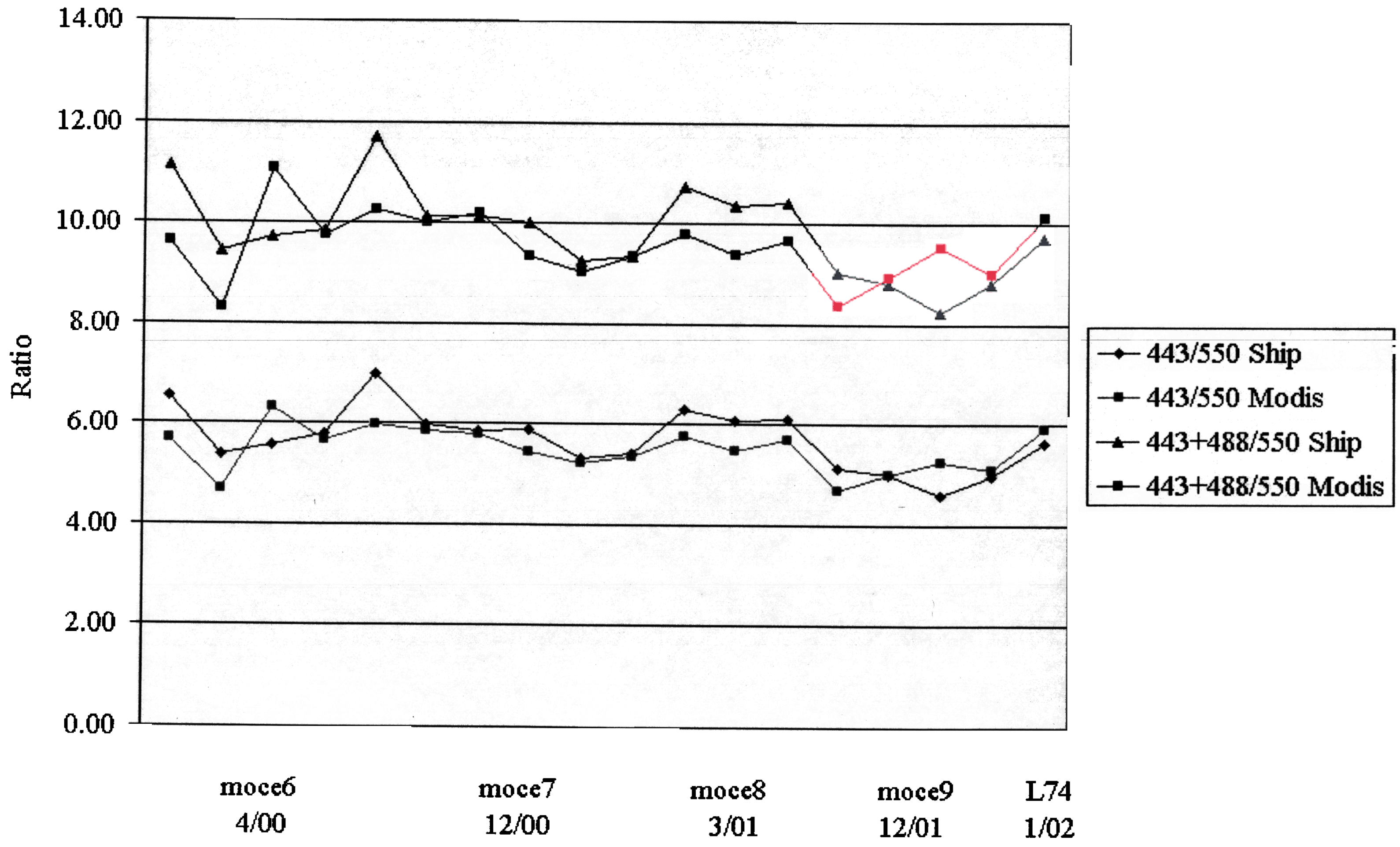


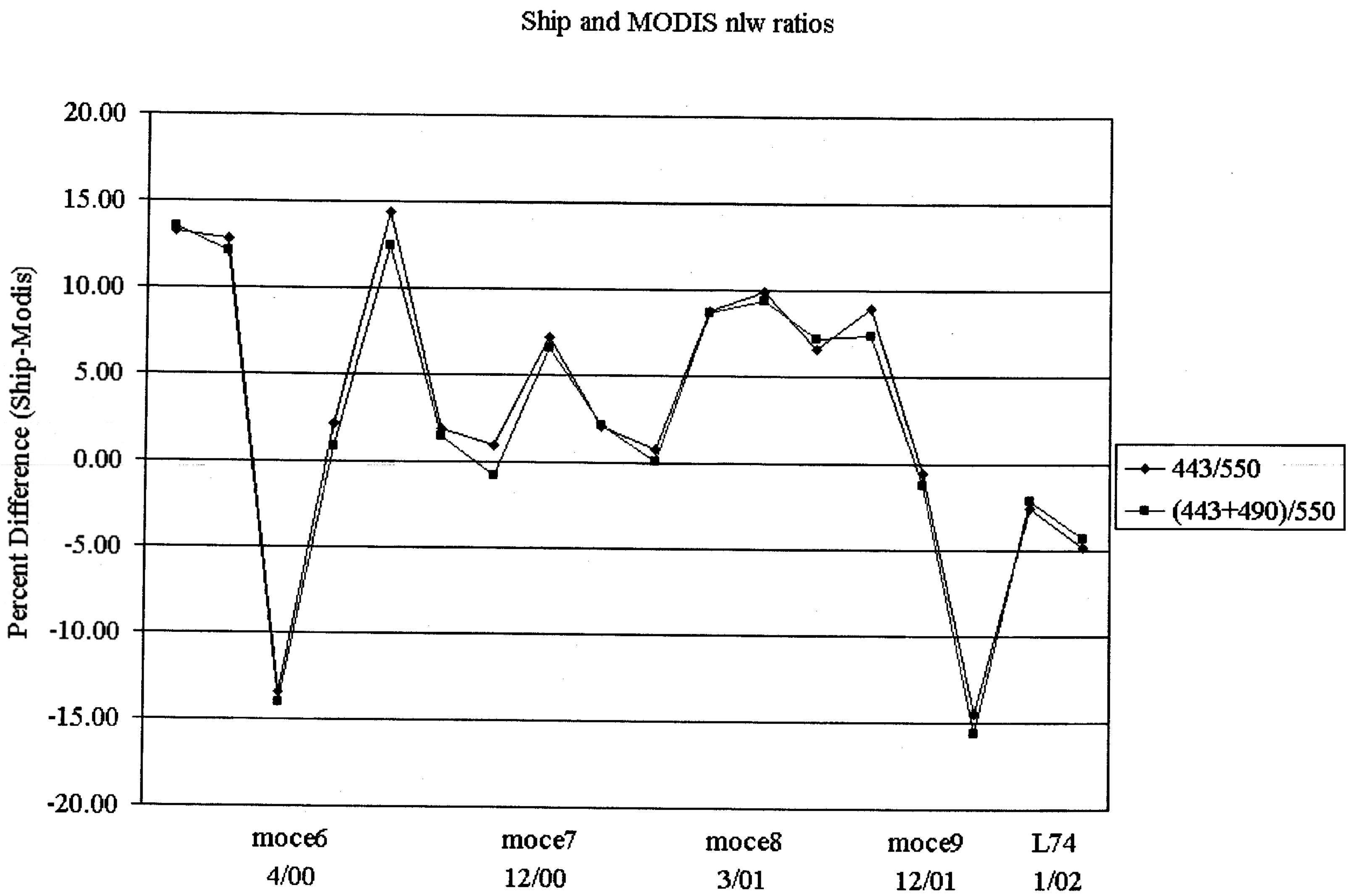
Ship and MODIS nlw
nlw (W/m2/µm)
25
20
15
10
5
0
443 Ship
443 modis
490 Ship
490 modis
550 Ship
550 modis
moce6
4/00
moce7
12/00
moce8
3/01
moce9
12/01
l74
1/02



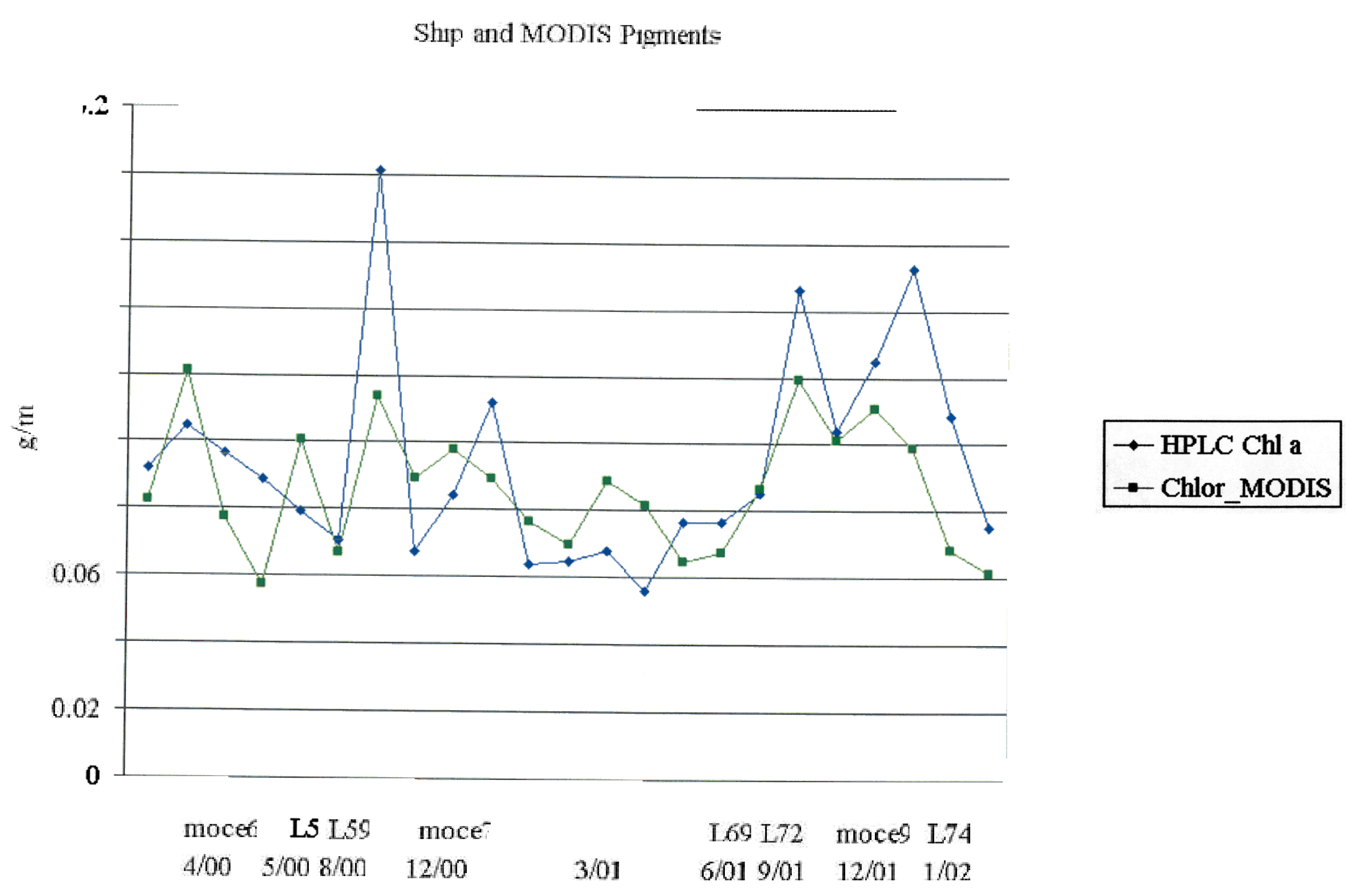
Ship and MODIS nlw
Percen Differen Shi -MODIS
30.00
10.00
0
10.00
-30.00
-40
moce6
4/00
moce7
12/00
moce8
3/01
moce9
12/01
L74
1/02
443 nm
488 nm
550 nm

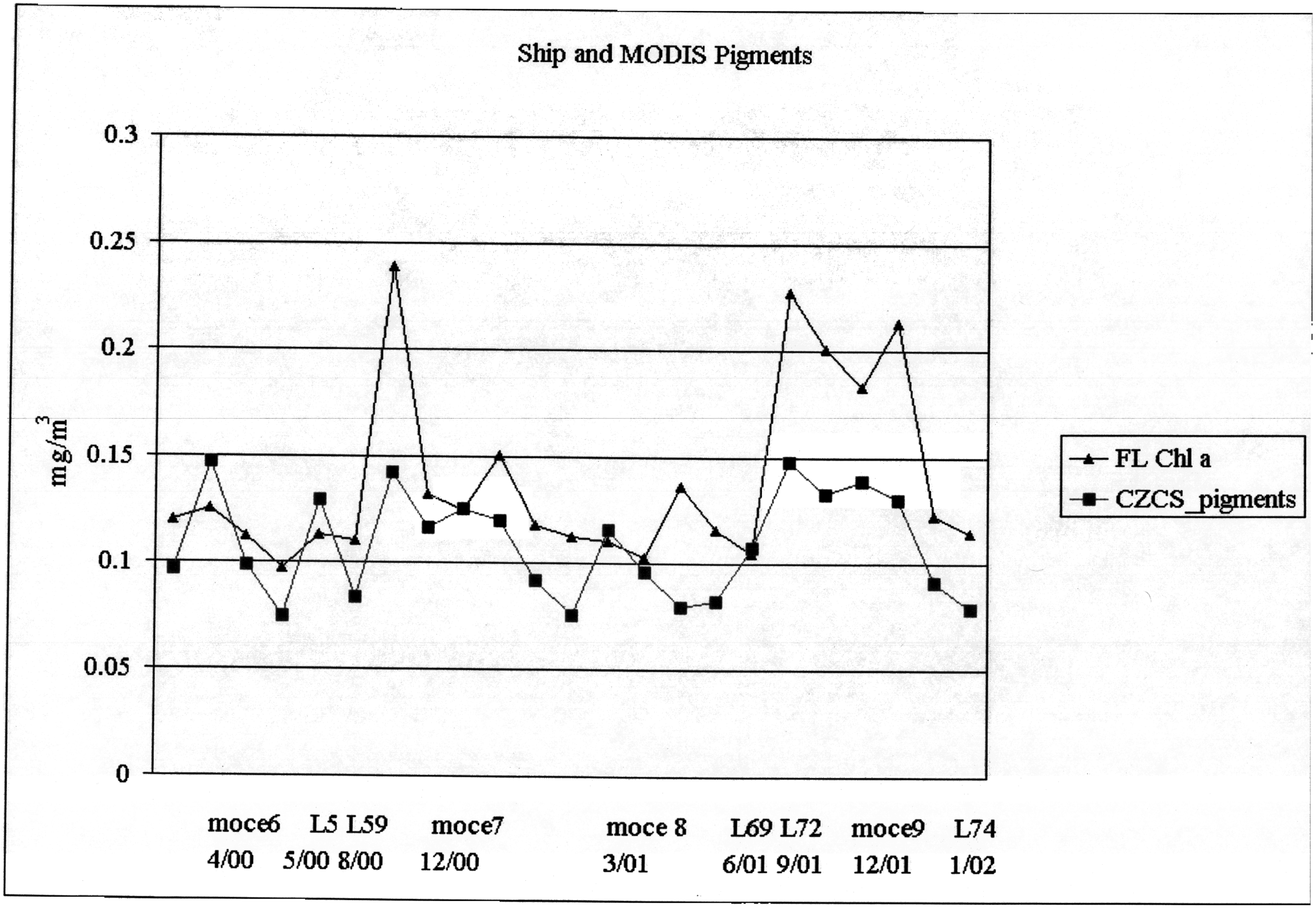
Ship and MODIS nlw ratios



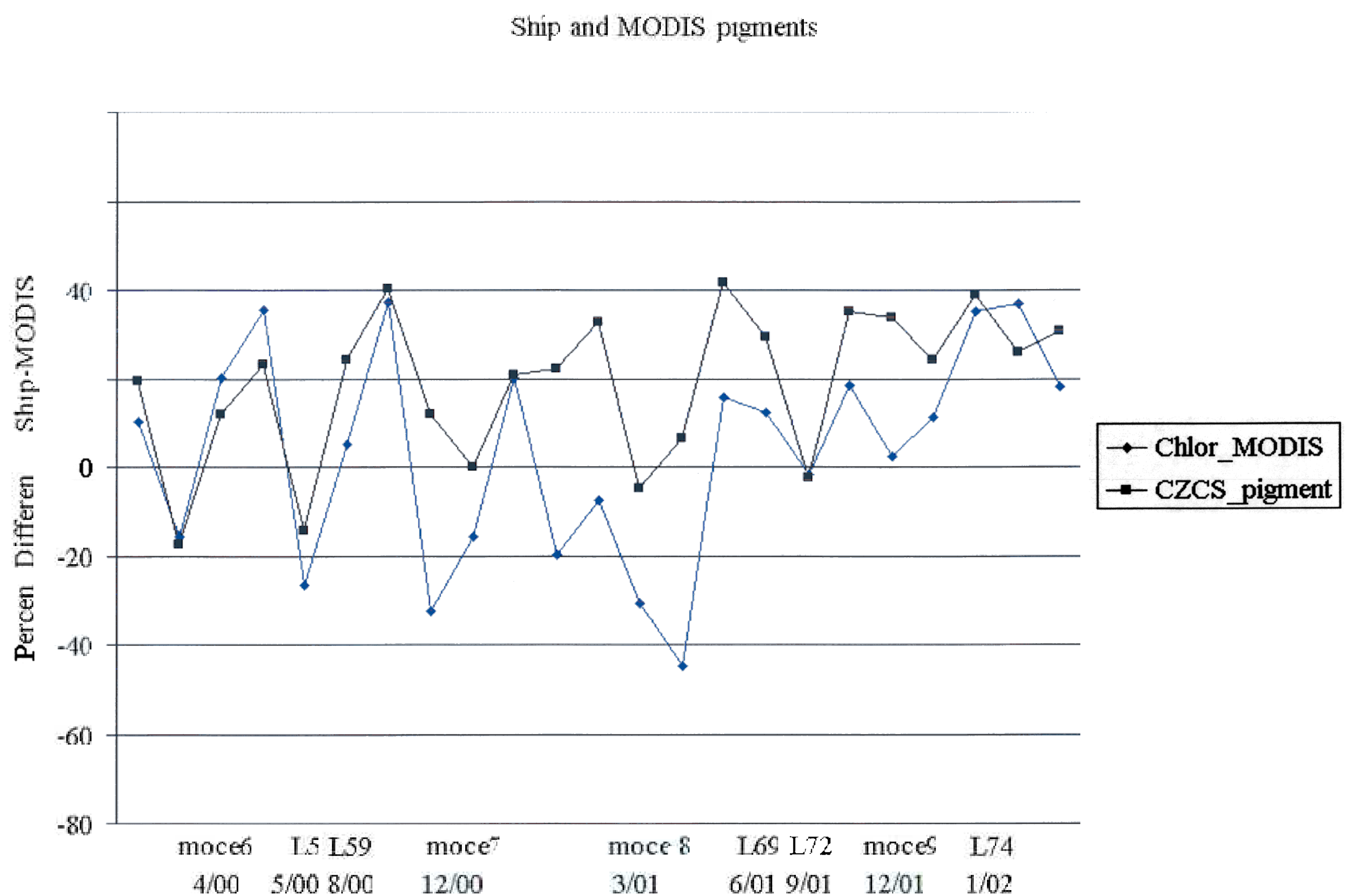


Ship and MODIS nlw ratios
Percent Difference (Ship-Modis)
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
moce6
4/00
moce7
12/00
moce8
3/01
moce9
12/01
L74
1/02
443/550
(443+490)/550


Ship and MODIS Pigments
g/m
0.2
0.06
0.02
0
moce6 4/00
L5 5/00
L59 8/00
moce7 12/00
3/01
L69 6/01
L72 9/01
moce9 12/01
L74 1/02
HPLC Chl a
Chlor_MODIS

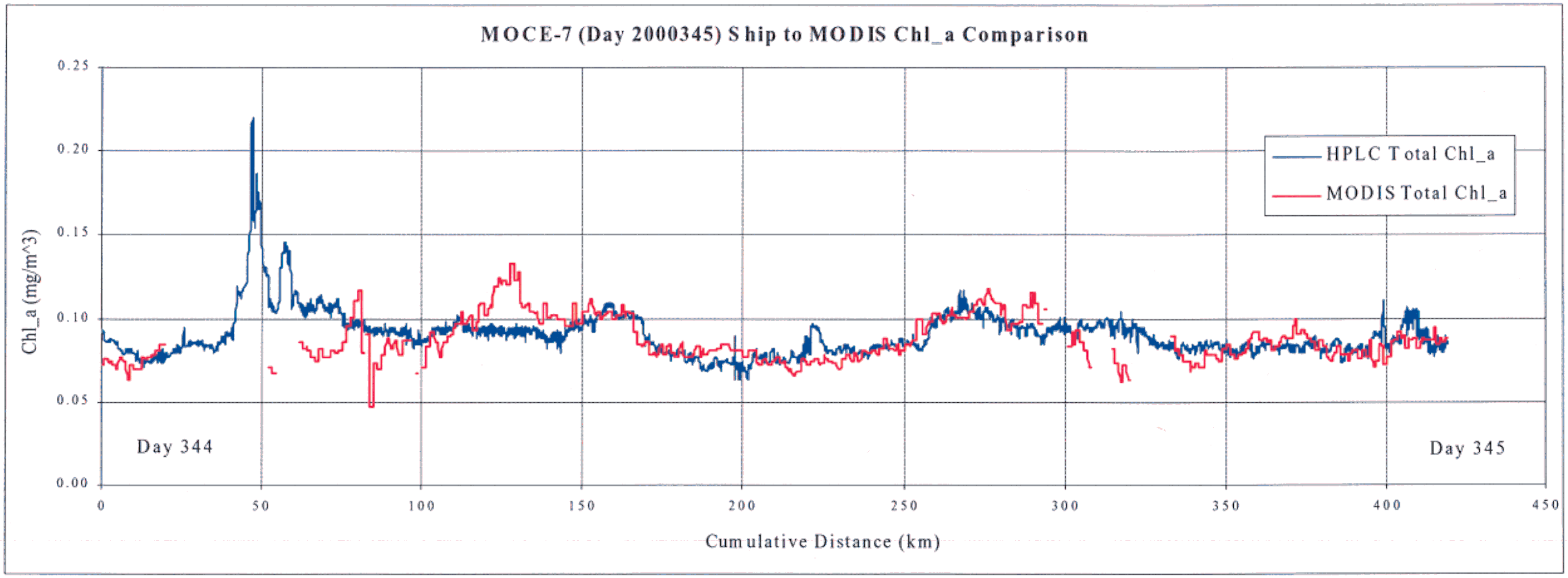


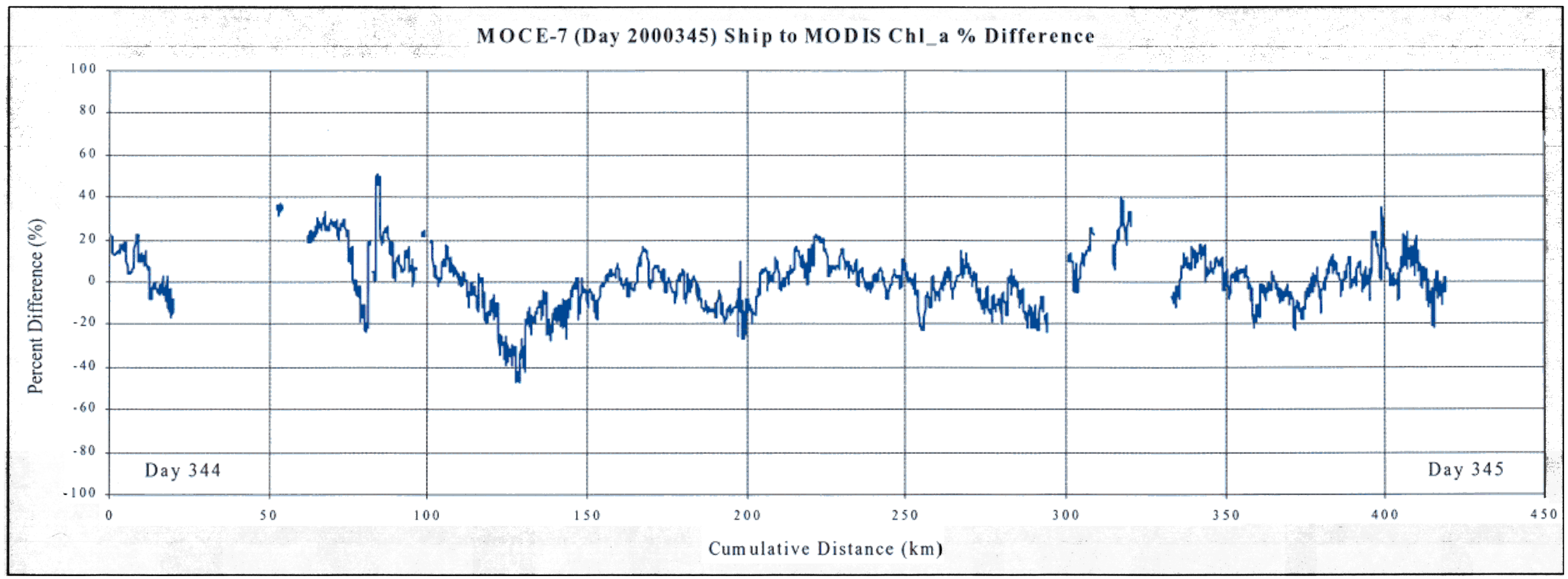
Ship and MODIS Pigments
0.3
0.25
0.2
0.15
0.1
0.05
0
mg/m3
FL Chl a
CZCS_pigments
moce6 L5 L59 moce7 moce 8 L69 L72 moce9 L74
4/00 5/00 8/00 12/00 3/01 6/01 9/01 12/01 1/02



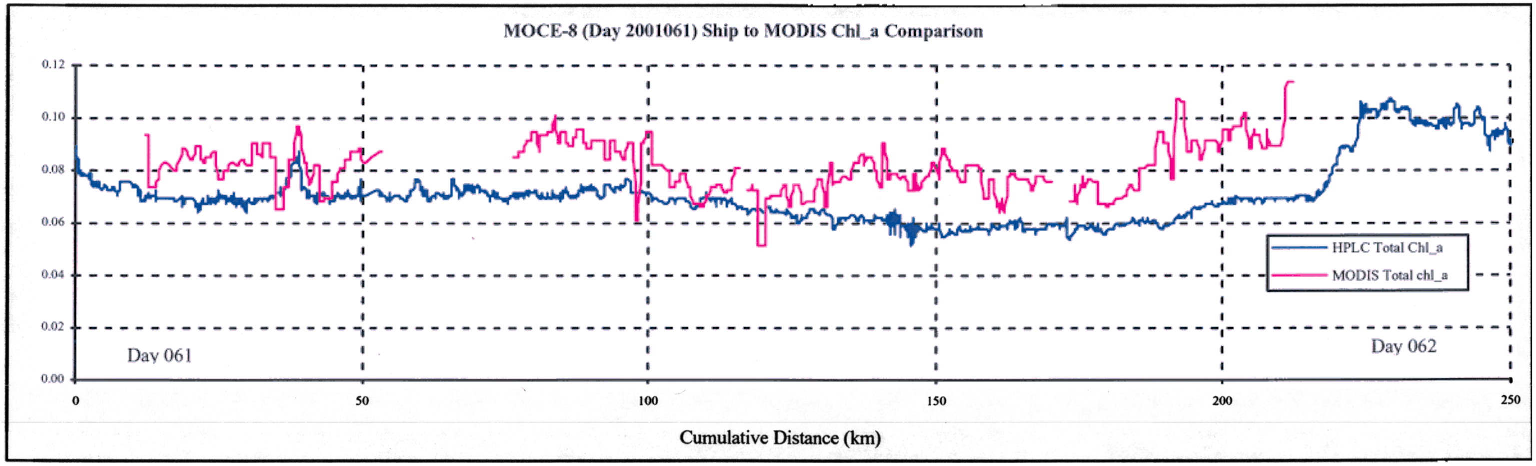
Ship and MODIS pigments
Percen Differen Ship-MODIS
40
0
-20
-40
-60
-80
moce6 4/00
L5 5/00
L59 8/00
moce7 12/00
moce 8 3/01
L69 6/01
L72 9/01
moce9 12/01
L74 1/02
Chlor_MODIS
CZCS_pigment

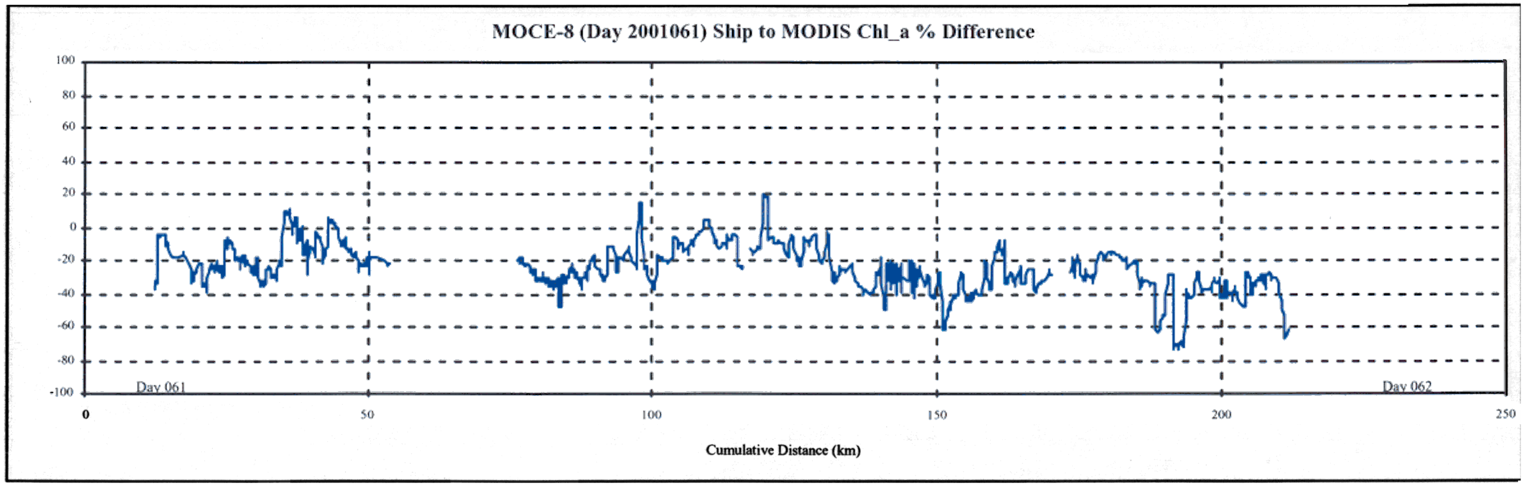
MOCE 7 - MODIS_Chl Ship Track

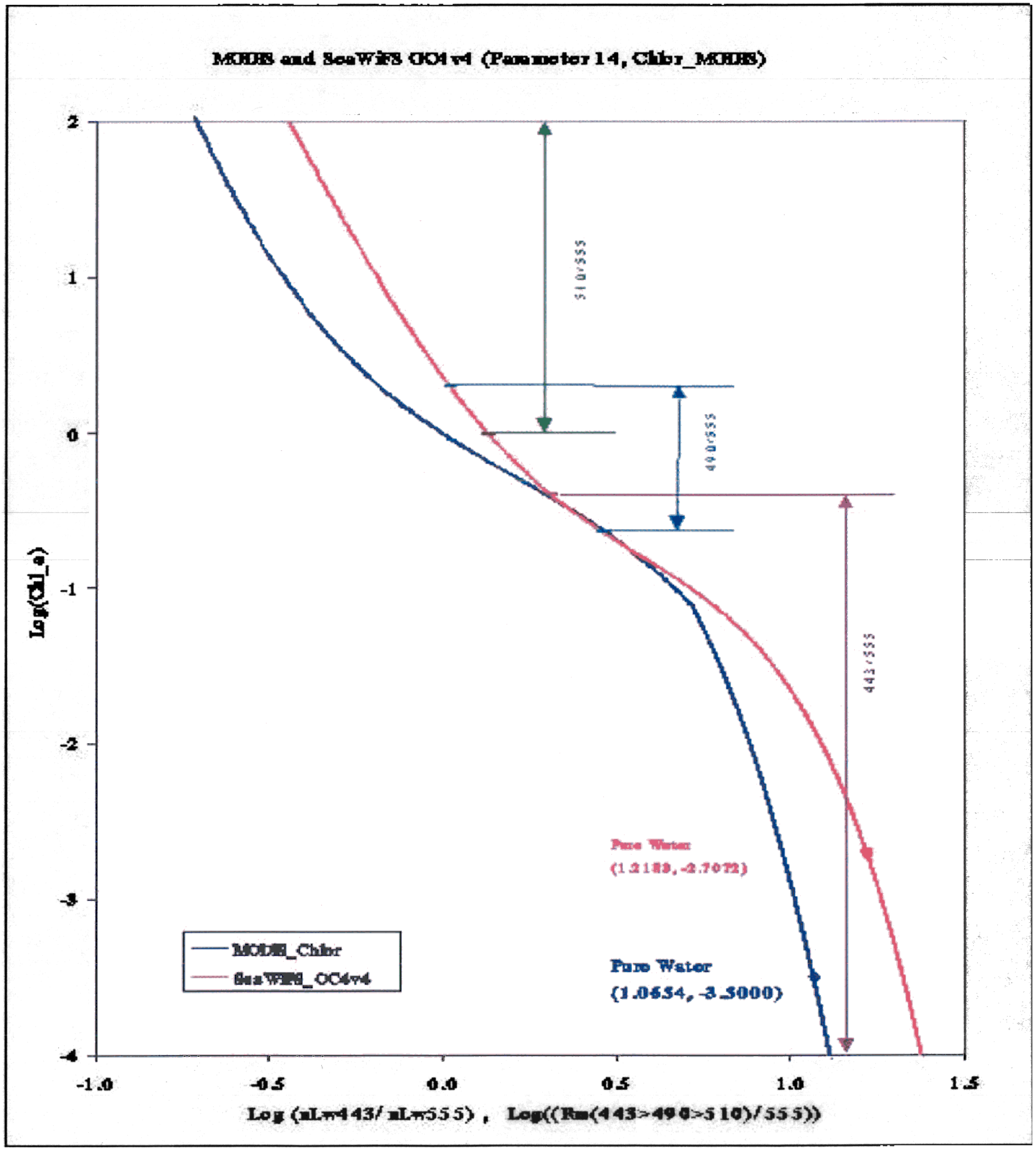




MOCE 8 MODIS Chl Ship Track






MODIS and SeaWiFS OC4v4 (Parameter 14, Chlor_MODIS)
2
1
0
-1
-2
-3
-4
Log(Chl_a)
-1.0
-0.5
0.0
0.5
1.0
1.5
Log (nLw443/ nLw555) , Log((Rrs(443>490>510)/555))
510/555
490/555
443/555
Pure Water
(1.2183, -2.7072)
Pure Water
(1.0654, -3.5000)
MODIS_Chlor
SeaWiFS_OC4v4

Present Status Future Validation

Recen M am charac er a on ca bra on re u have o ved mos of he major nLw re r eva p ob m

Pre en produc are compu a ona y va da ed and n a va da on e u nd ca e ha he p gmen re r eva a e w h n 30%

MOBY ob erva on now ope a ona for Aqua

Ju y Two ca va da a e w h Mod Terra Aqua &SeaW FS overpasses

MOD S Va da on n a a on cru ses chedu ed for Sep and Oc 2002 n he Chesapeake Bay and Hawa

APPENDIX 6

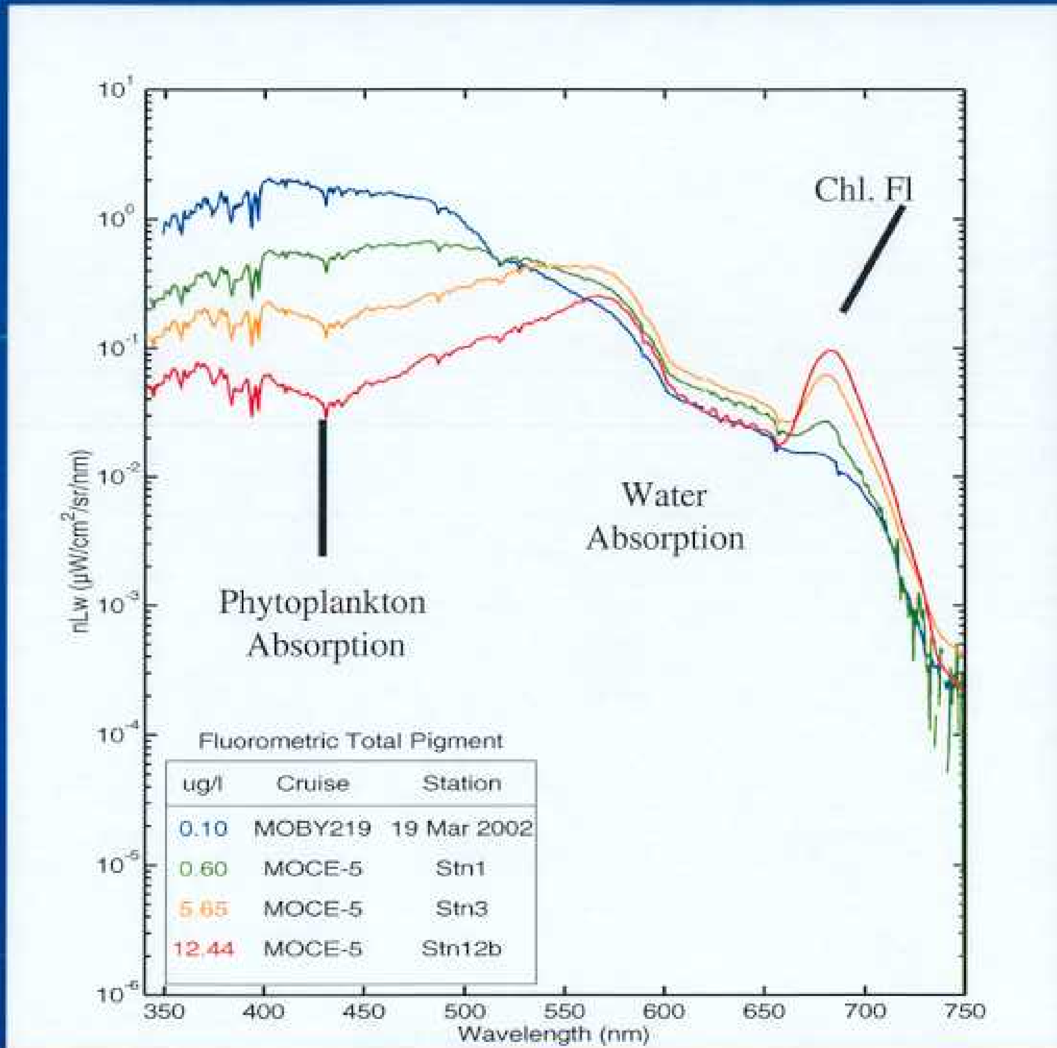
Climate Quality Ocean Color Time Series: MODIS-SeaWiFS MOBY Vicarious Calibration

Dennis Clark & Robert Evans
with
MOCE/MOBY Team Members
NOAA/NESDIS
Office of Research and Applications

E. Kearns and K. Kilpatrick
Rosenstiel School of Marine and Atmospheric Science
University of Miami

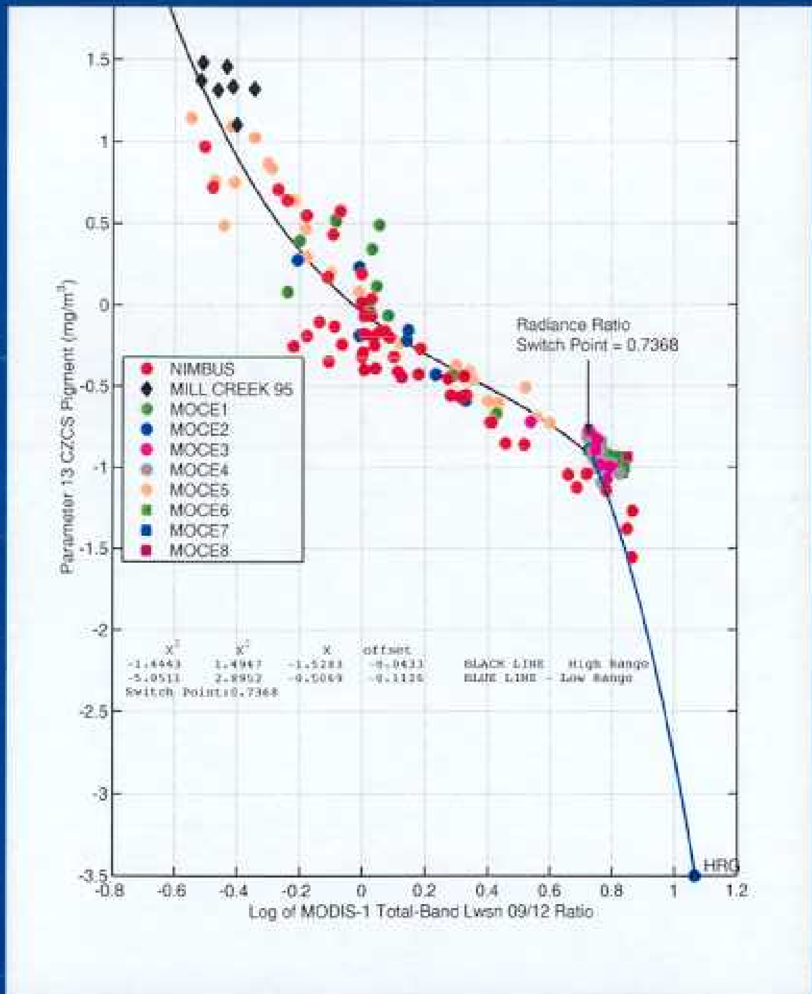
IWG Meeting 18 November 2002

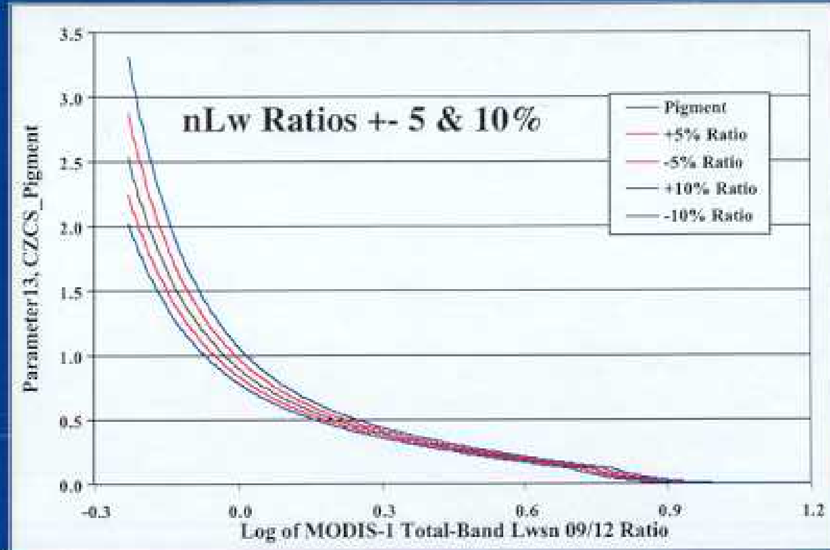
Water-leaving Spectral Radiance Distributions “Ocean Color”

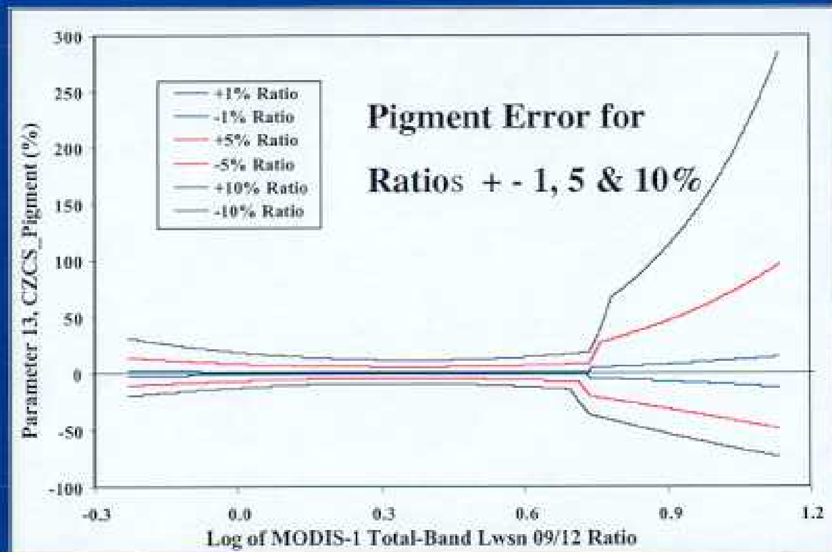


Ocean Color Variability is Dominated by the Suspended and Dissolved Matter of Biogenic Origin.

Empirical Pigment Product - Ratio Uncertainty



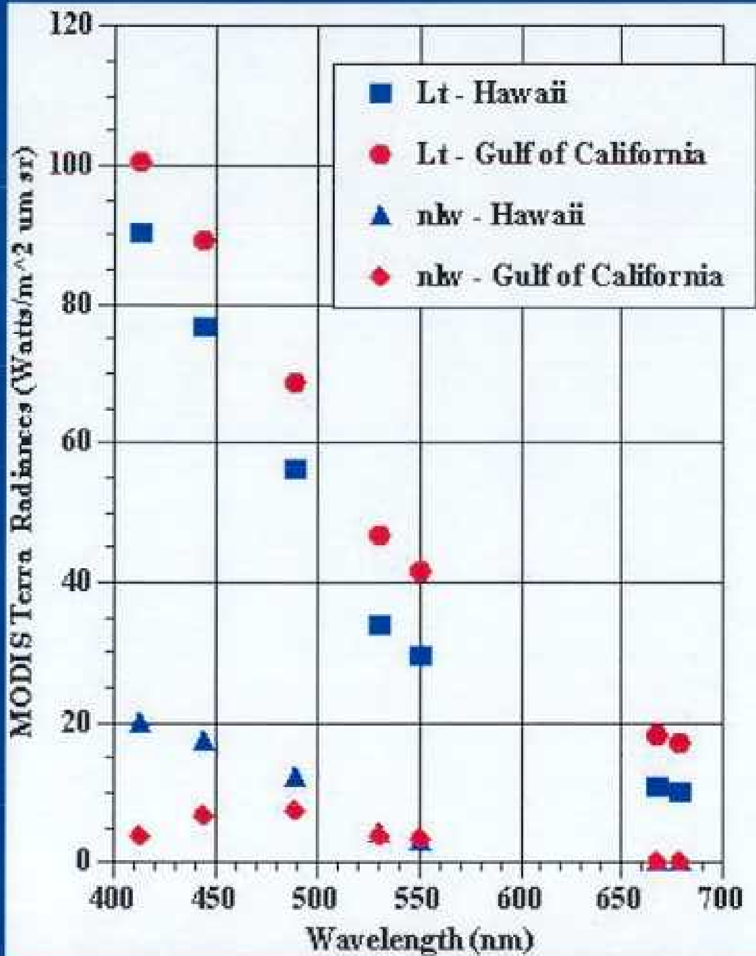


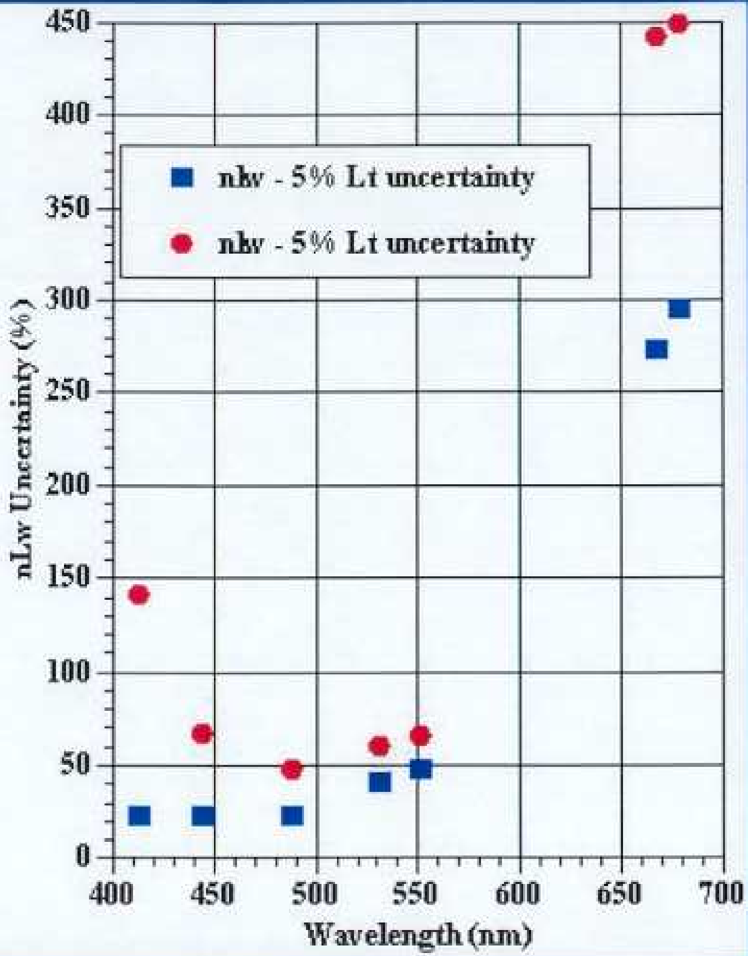


Water-leaving Radiance Retrieval Uncertainty

SeaWiFS - NIST Calibration 4% MODIS ≤ 5%

Assume Atmospheric Correction is Perfect



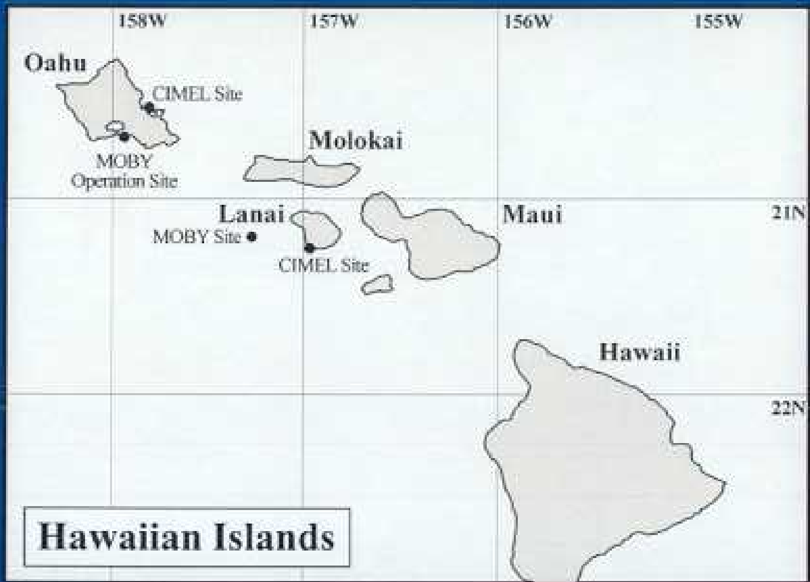


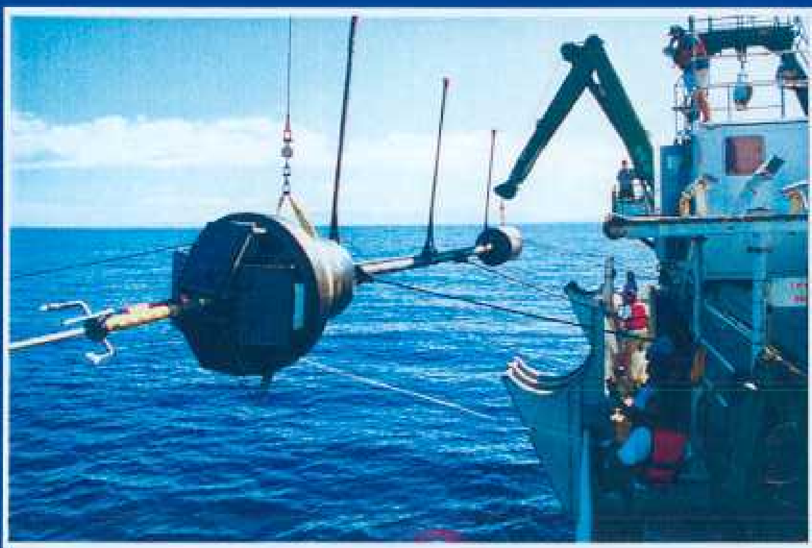
Vicarious Calibration Required for Ocean Color Science

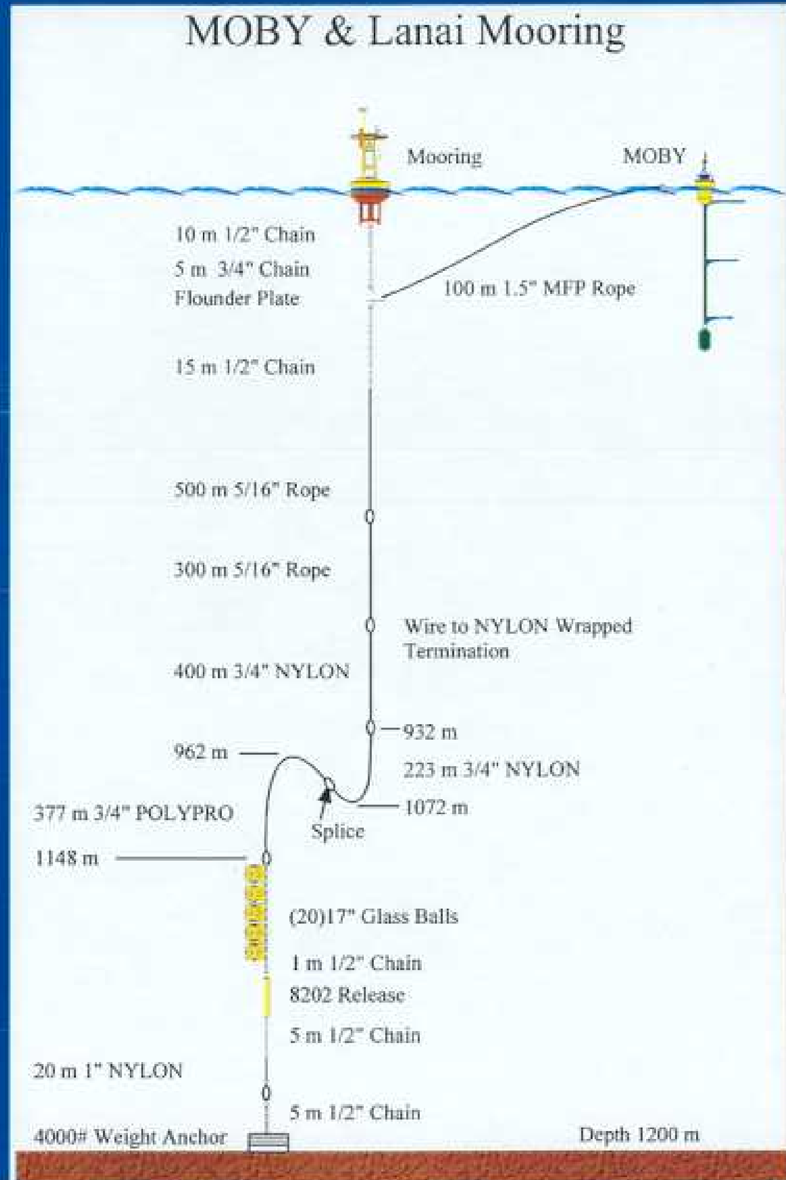
Laboratory and On-board Sensor Calibrations Cannot Meet the Accuracy Requirements for this Science Application.

A Minimum of an Order of Magnitude Improvement in Calibration Accuracy is Required.

MOBY Mooring Site







MOBY Operations Site - Univ. Hawaii

Pier Side - 30,000 sq. ft

16 Portable vans/tent

offices, shops, storage, labs (calibration, optics assembly, filtration)

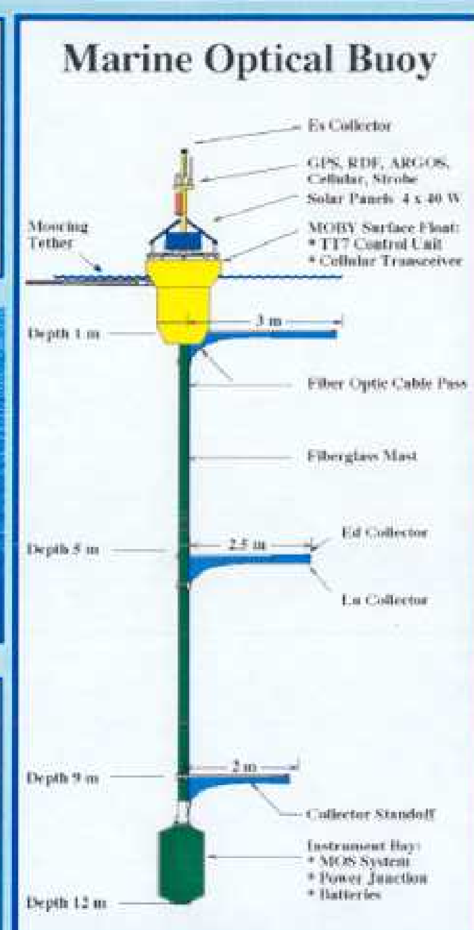
6 Shipboard Vans

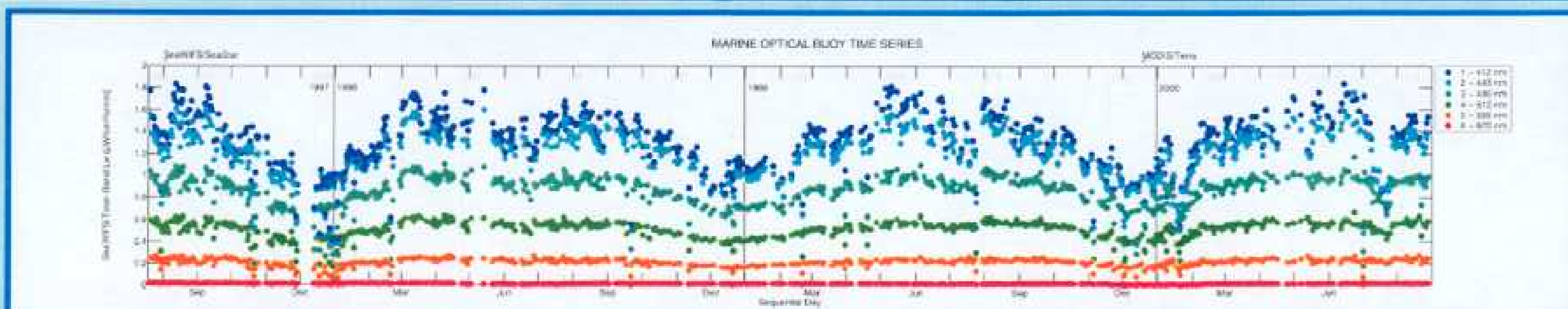
3 labs - (wet, optics, data acquisition) power, storage, & office

Pier side Support - cranes, machine shop.

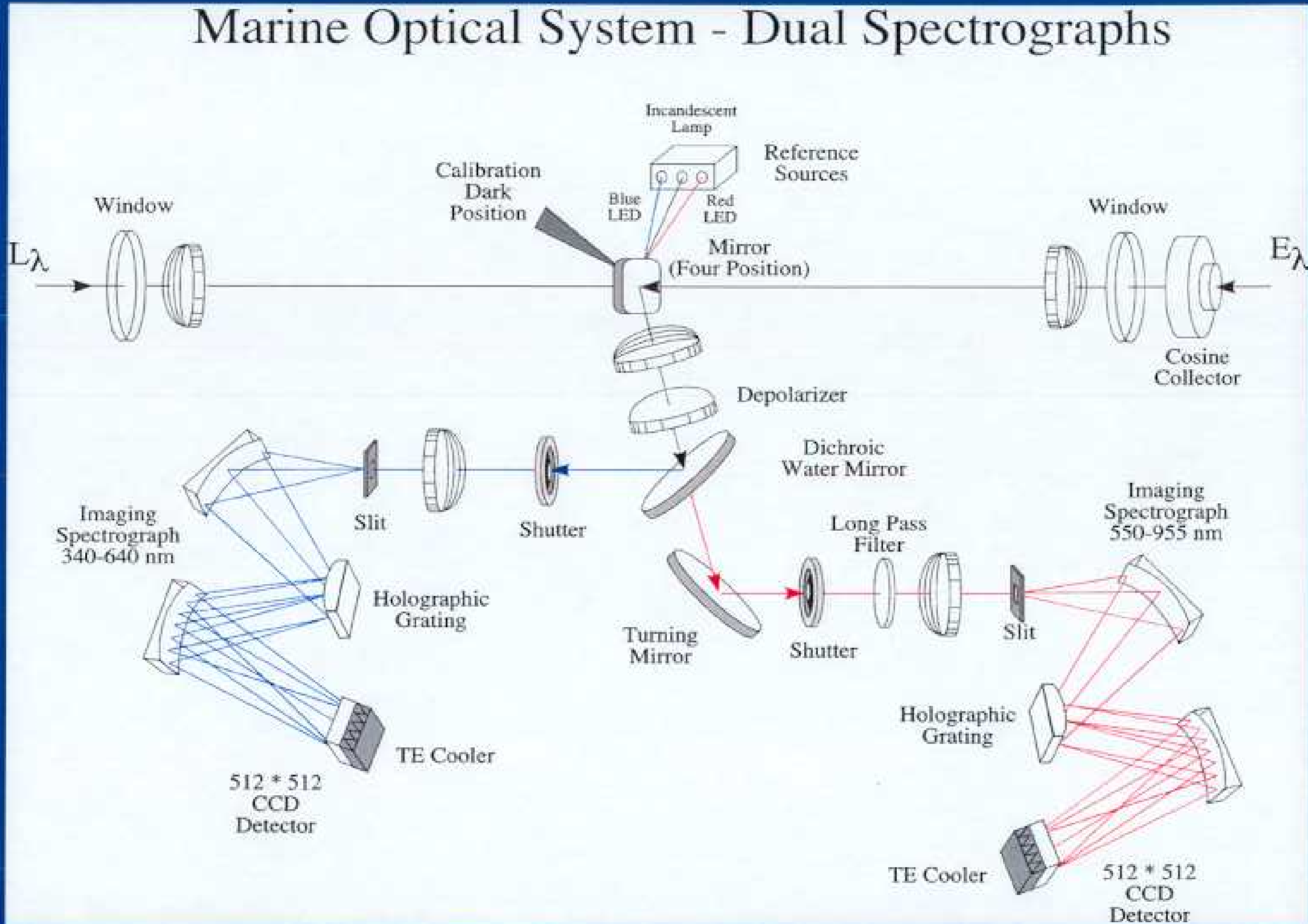
MOBY Instrument and spectral Time Series of MODIS ocean color bands

Accuracy ~3-5%

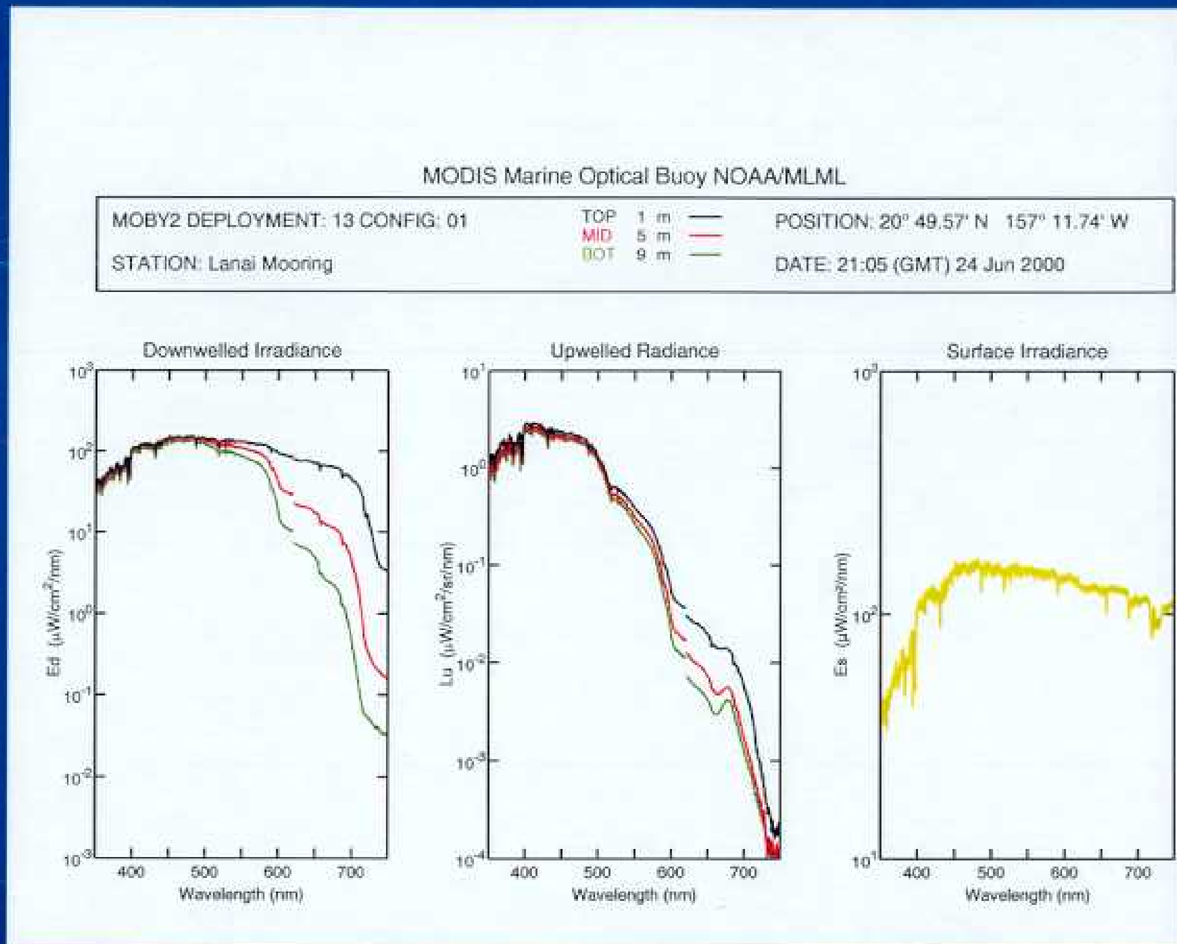




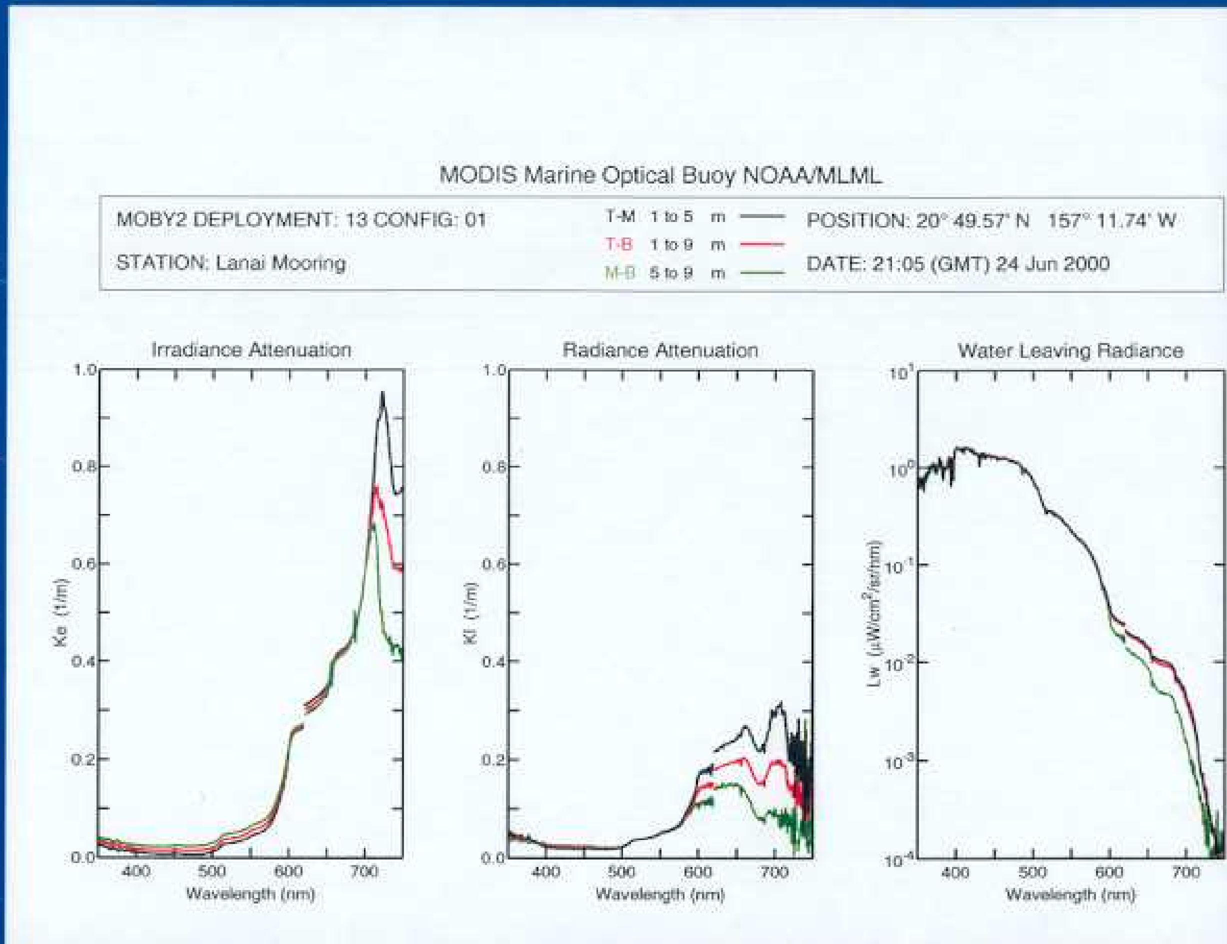
MOBY Optical System



MOBY Spectral Radiances

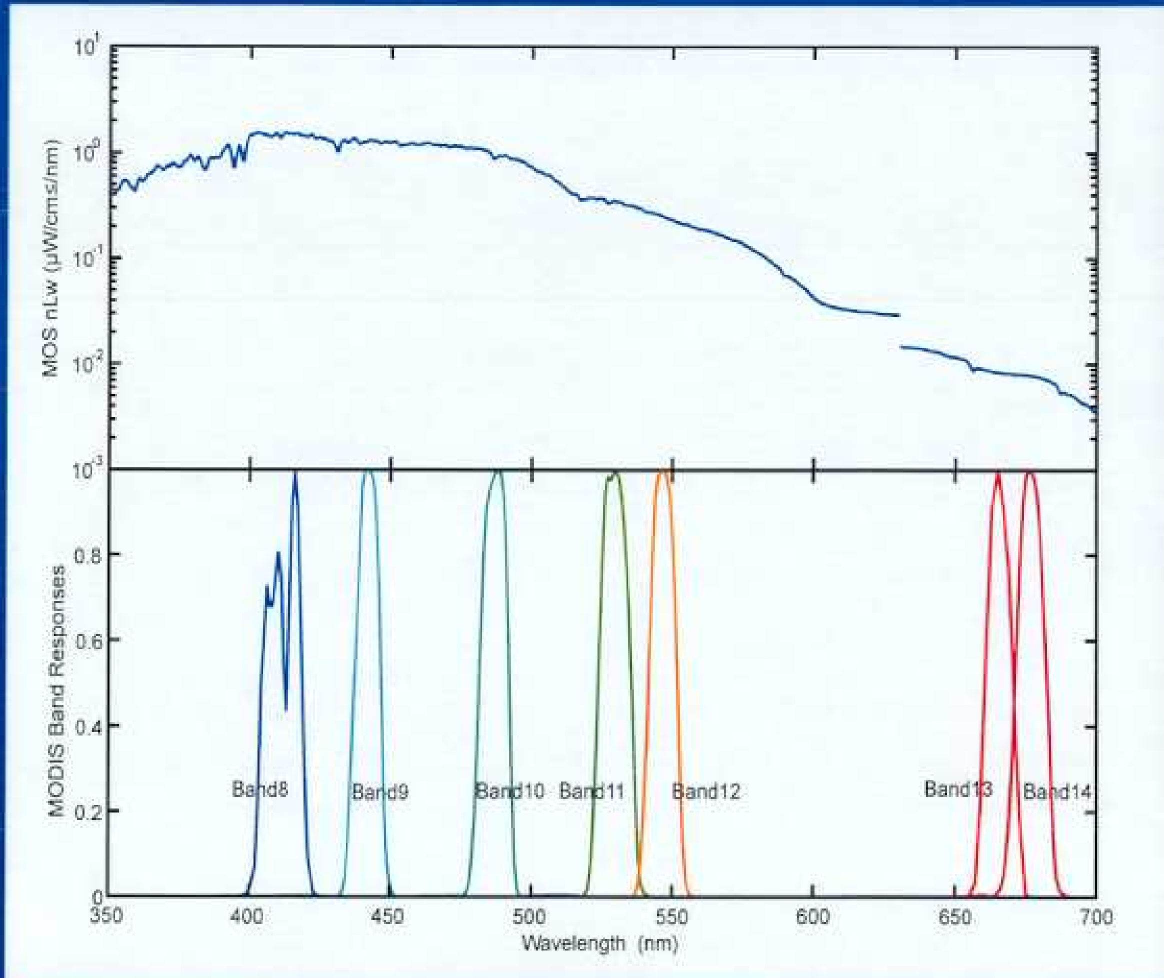


MOBY Attenuation Coefficients & Water-leavings Radiances

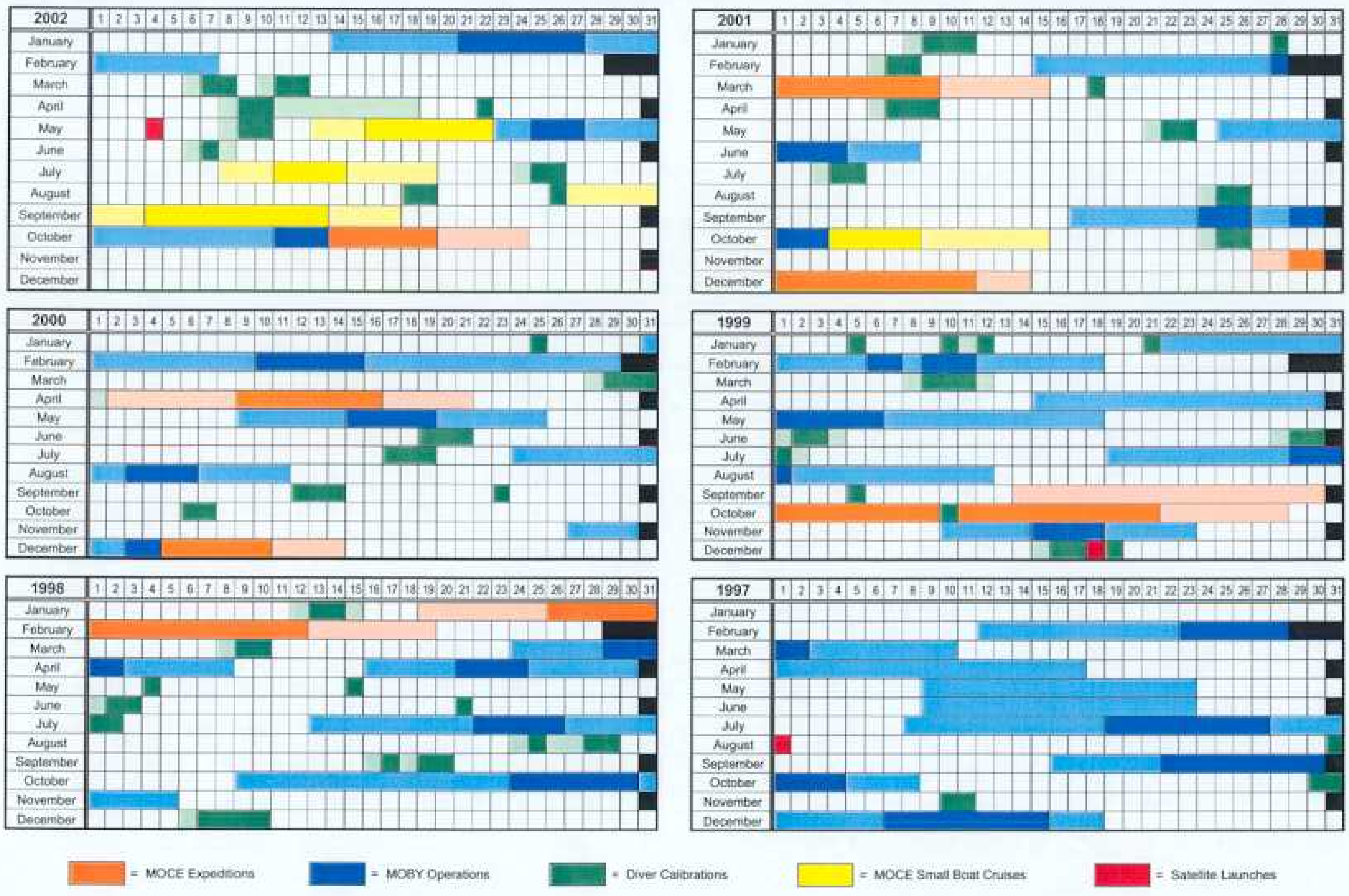


Spectral Band Pass Matching

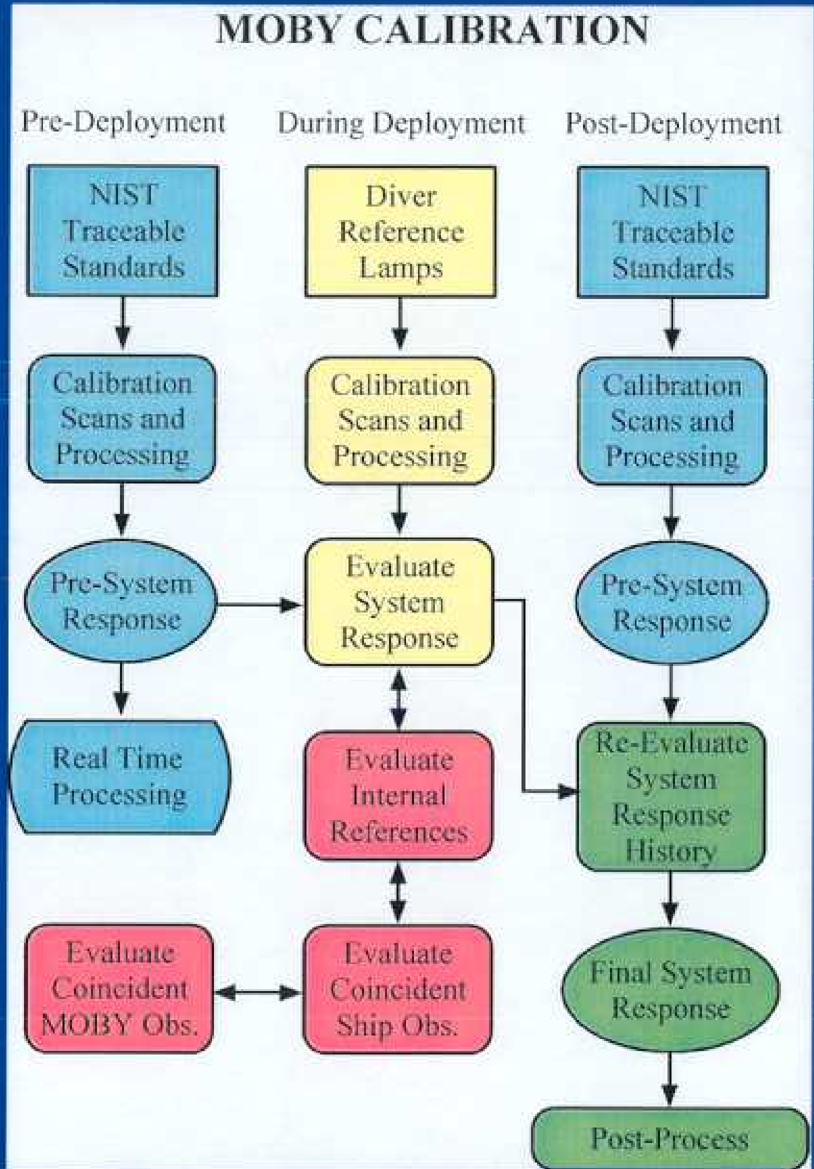
High Resolution Spectra Convolved to Sensor's Spectral Band Pass



MOBY/MOCE Activities 1997-2002



MOBY Calibration Process



NIST Collaborations

Training

NIST Primary Lamb Standards

Annual On Site Calibration Systems Check

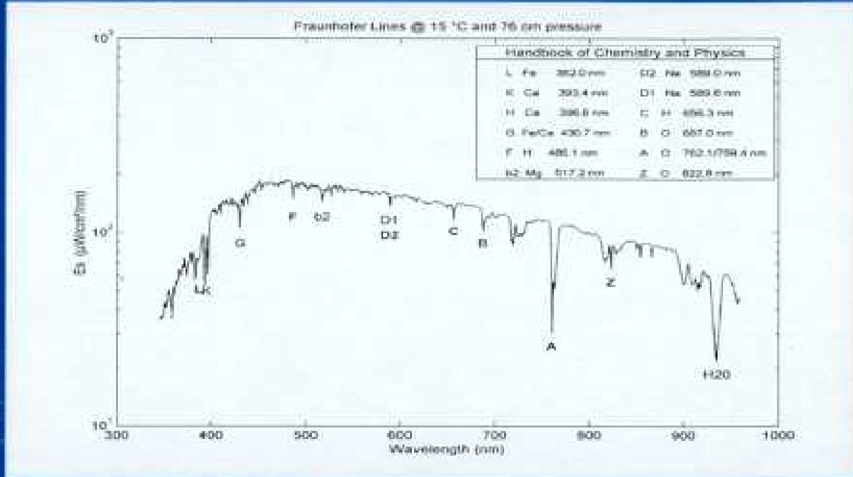
Pre/Post Cal. System monitoring with NIST Cal. Radiometers

SIRCUS - Stray Light Characterizations on MOBY and Shipboard Spectrometers

MOCE Calibration Systems (OL420 & OL425) now Calibrated at NIST

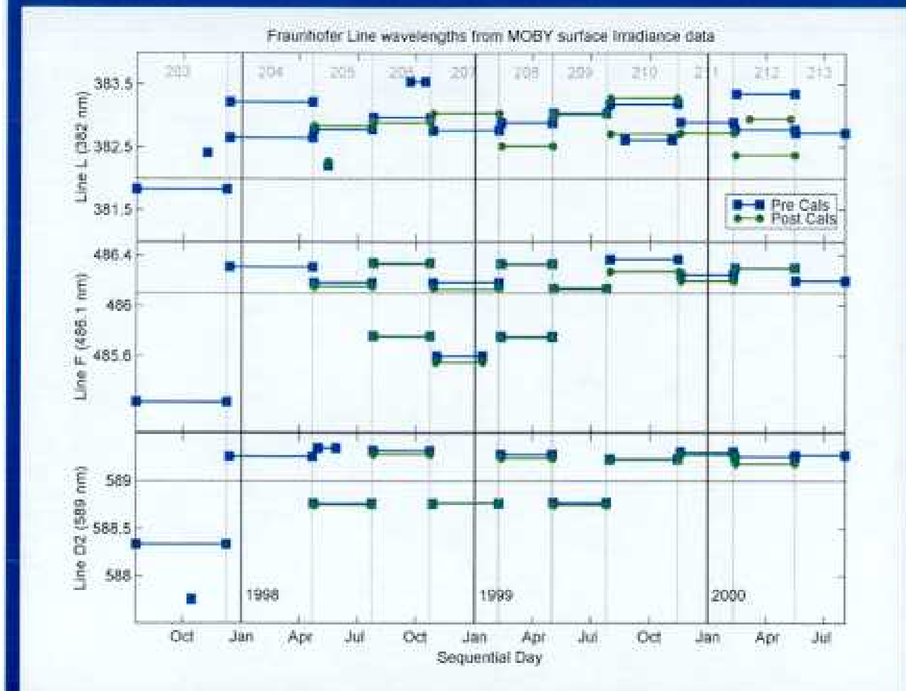
Initiating the development of new Radiometric Calibration Sources for Oceans

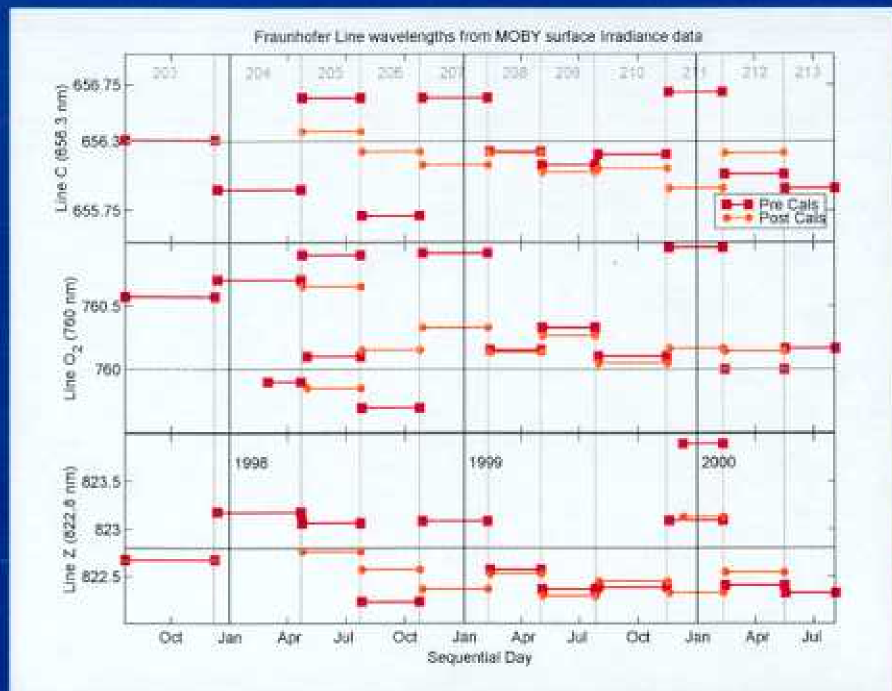
Spectral Calibration QC-Solar



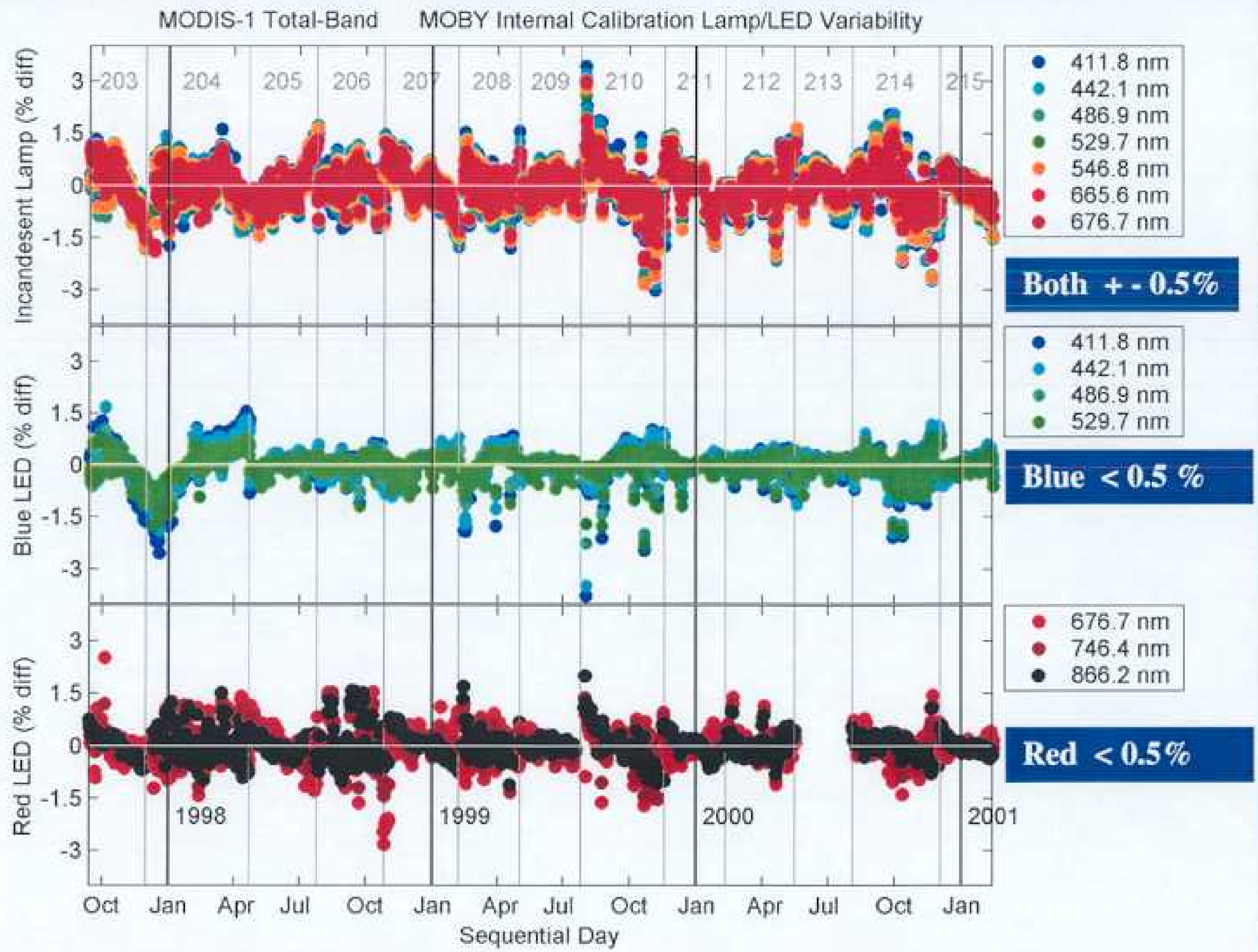
Blue Spectrograph
2.5 years
Approx. +- 0.6nm

Red Spectrograph
2.5 years
Approx. +- 1nm

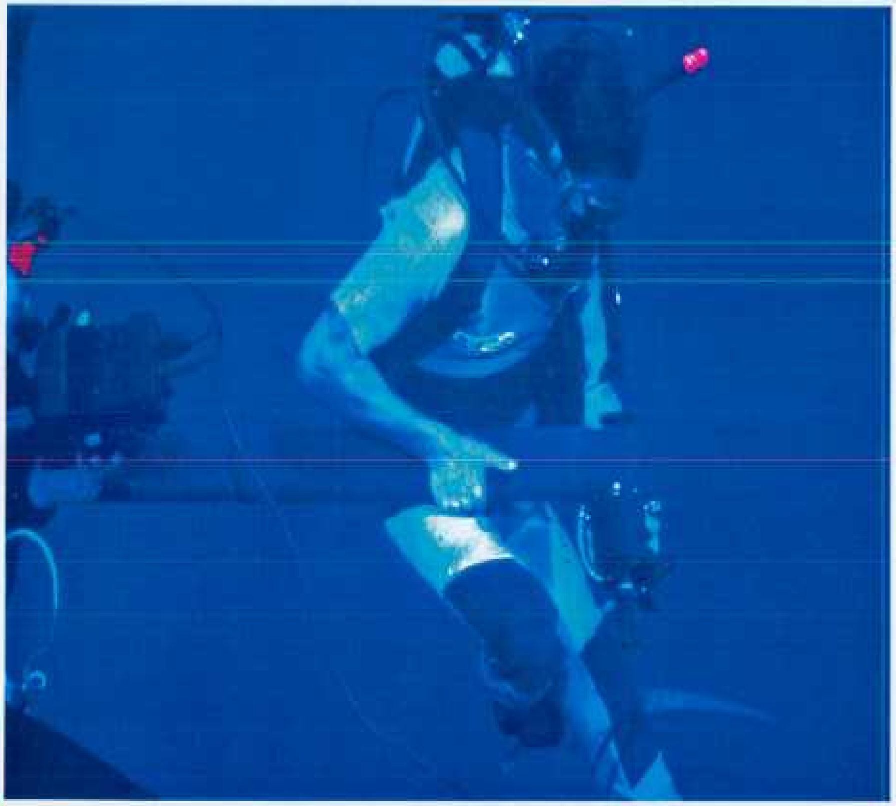


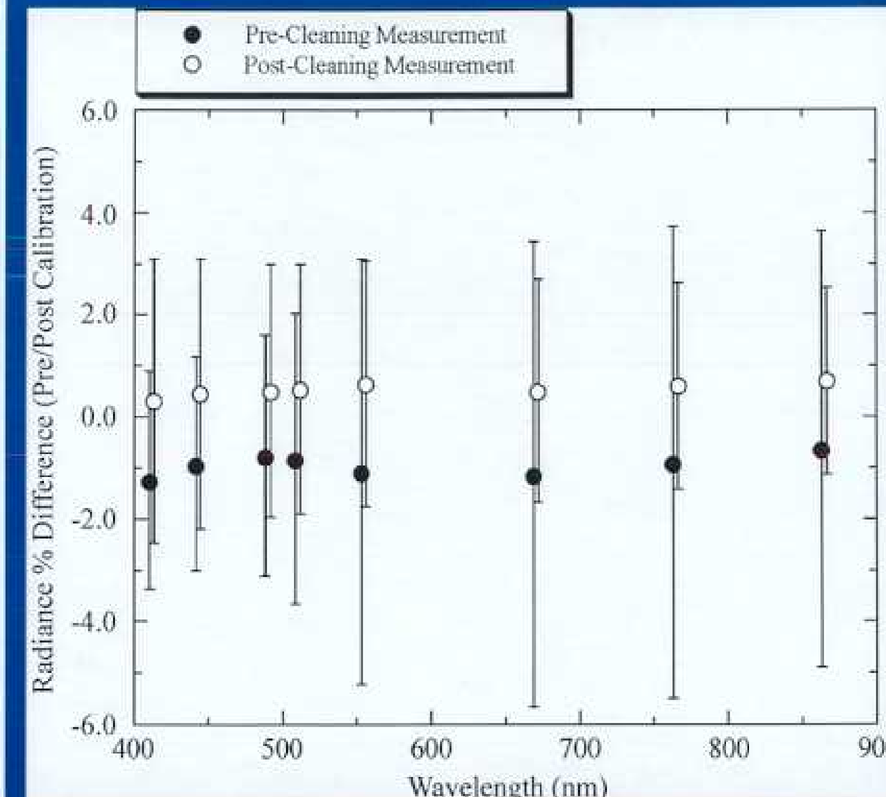


Internal Reference Lamps - Stability QC



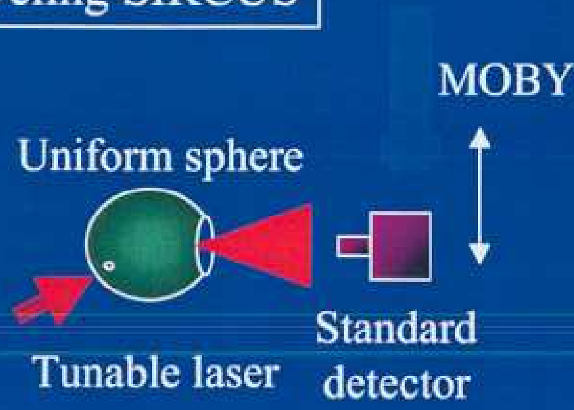
Diver Reference Lamp - Pre/Post Cleaning QC



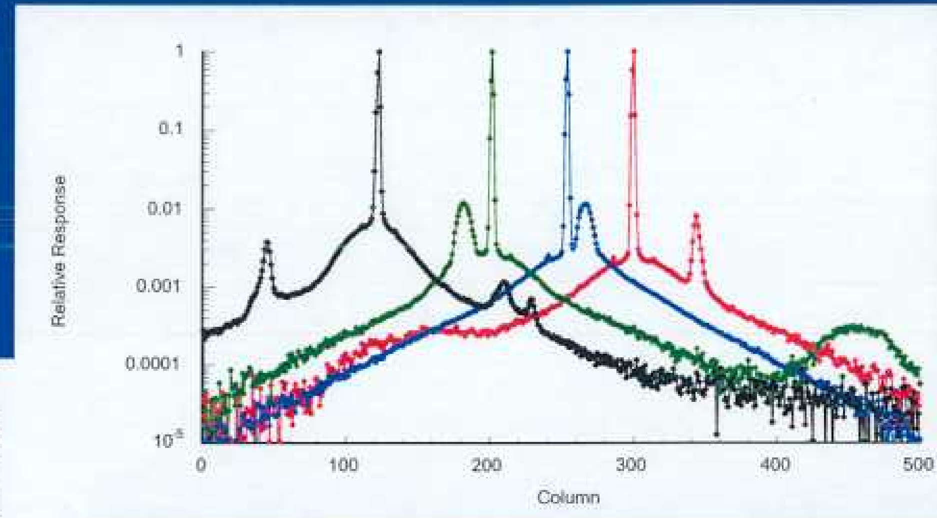


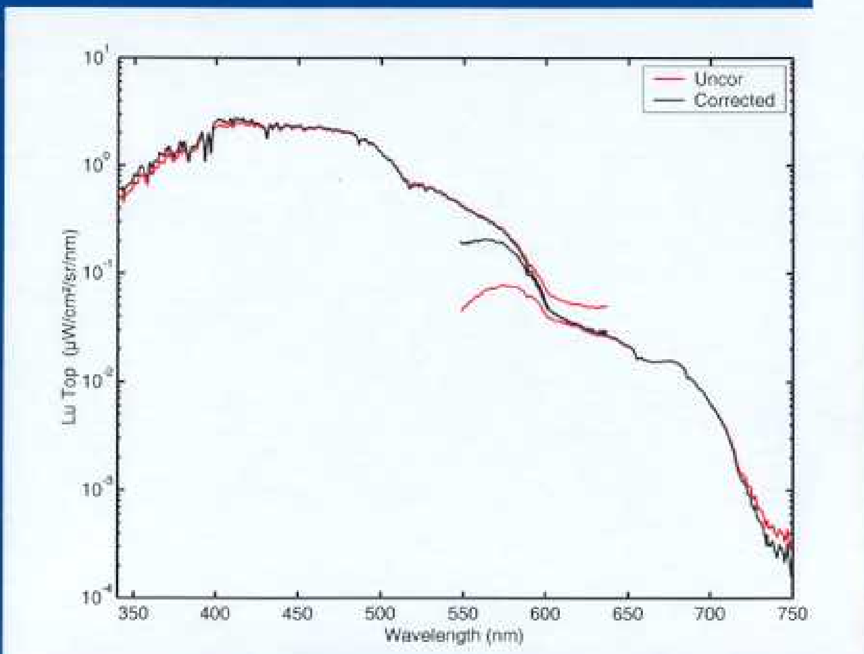
Stray Light & MOBY

Traveling SIRCUS



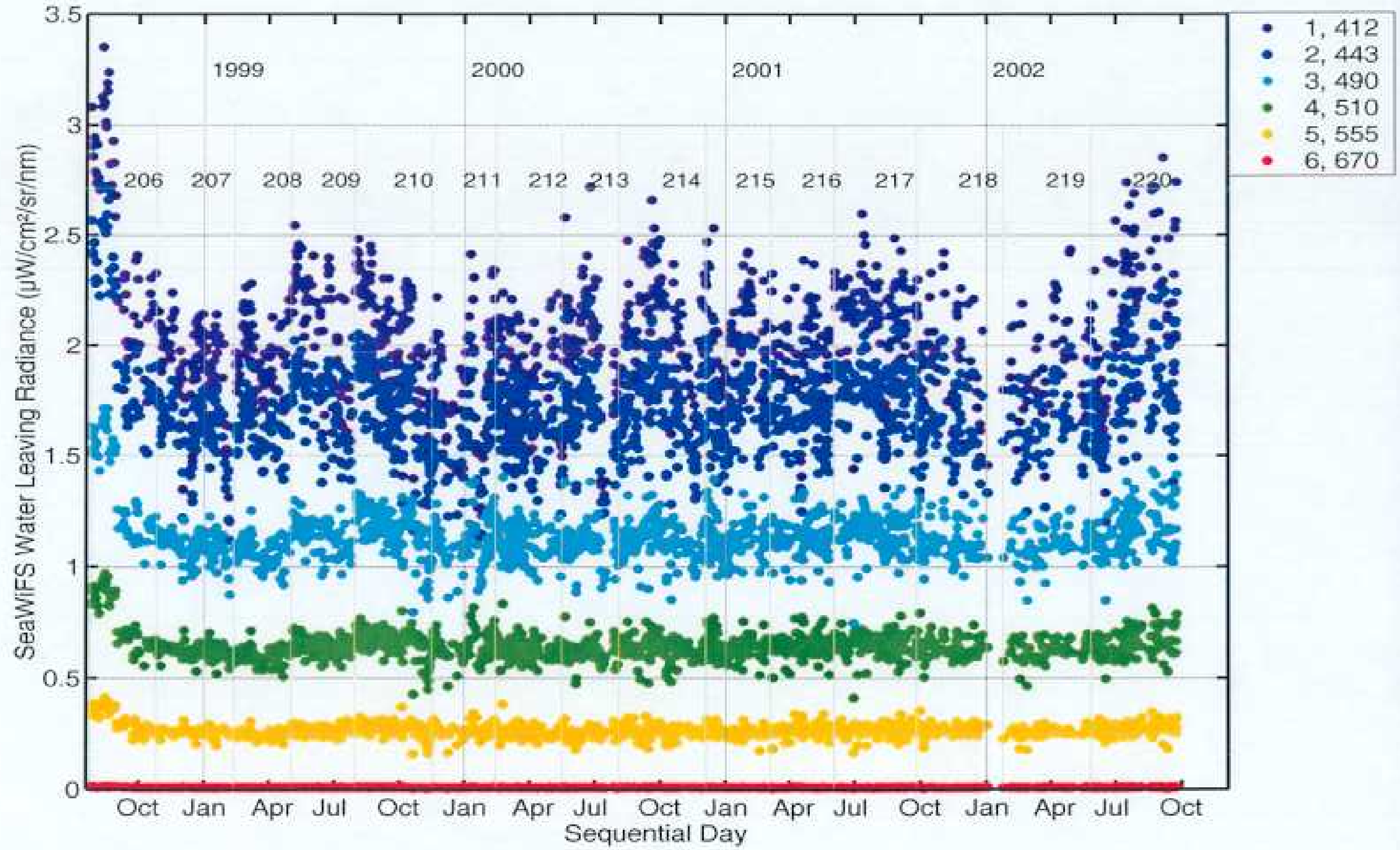
Response found at many wavelengths



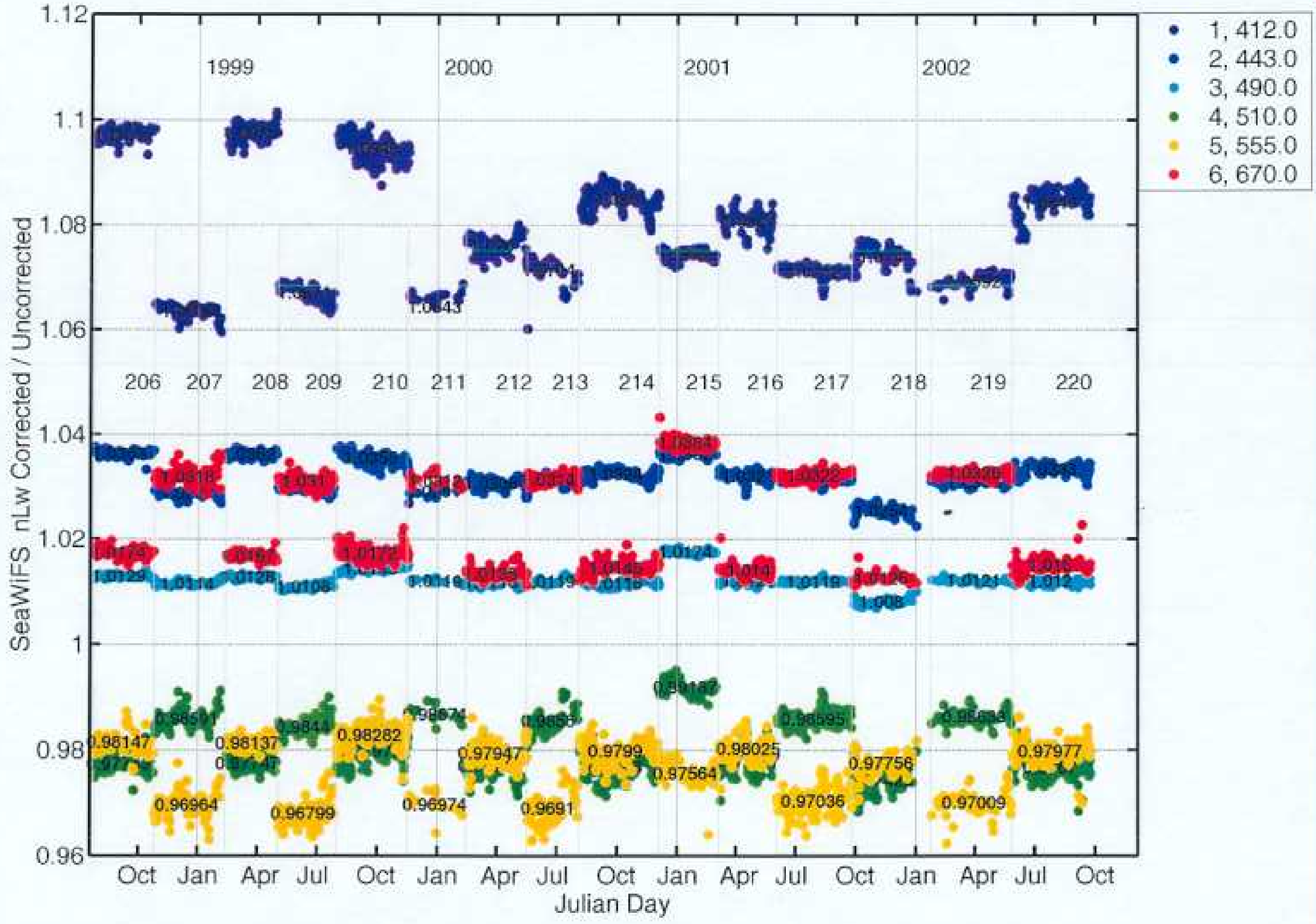


Corrected Lu's
-increase in UV
-better agreement in overlap region

MOBY Stray Light Corrected Time-Series - SeaWiFS Bands



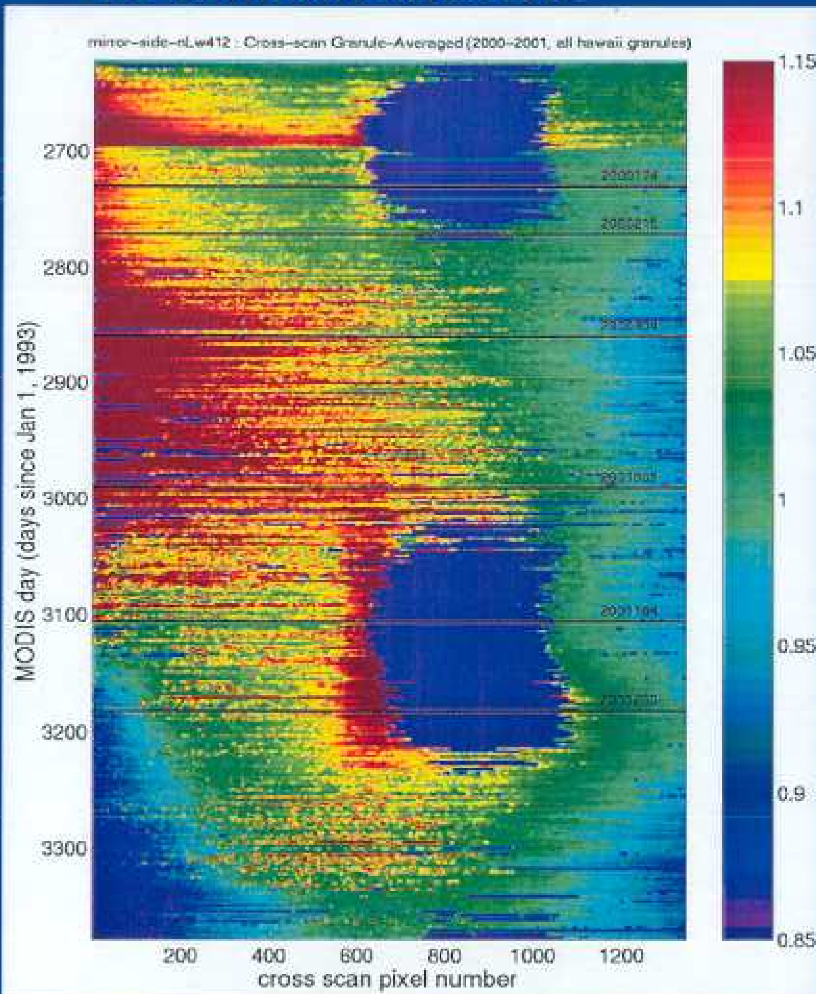
SeaWiFS Stray Light Time Series Corrections



Terra Mirror Side 1 to Mirror Side 2 Ratio
Cross-scan vs Time Gain Change (Percent Error)

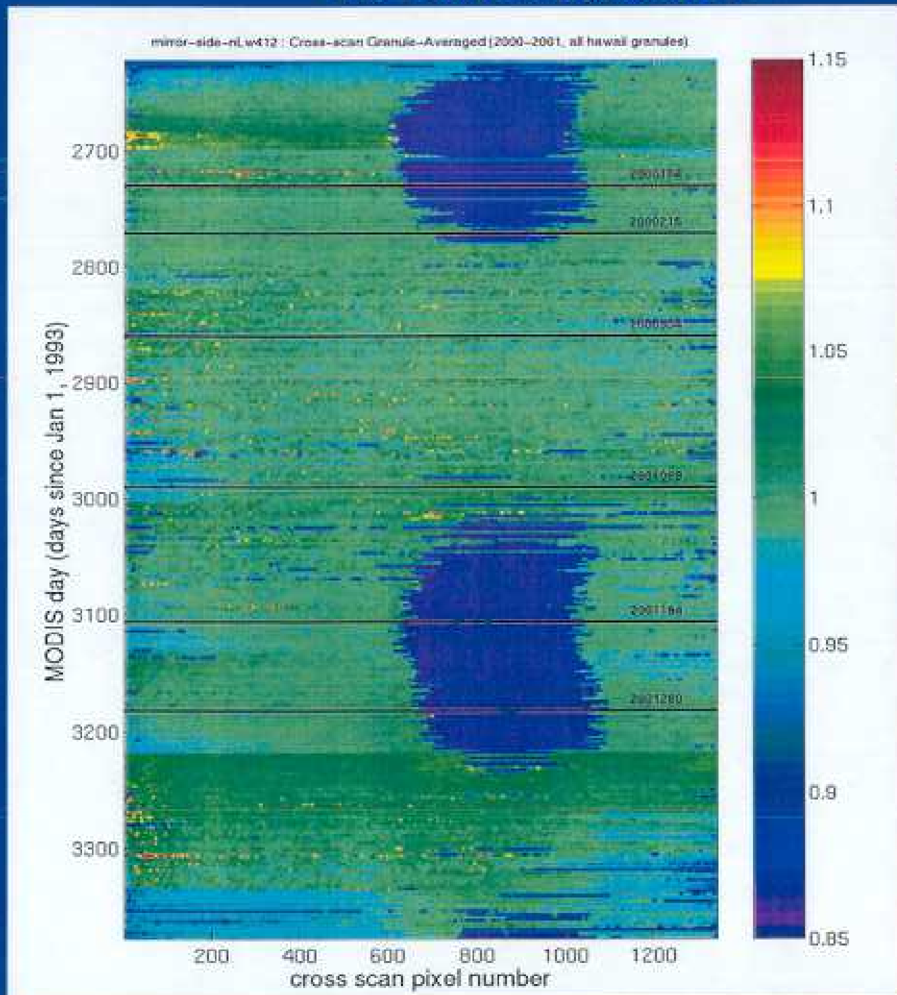
NOTE: Calibration is an ongoing process, instrument character changes ~ every 3 months

412 nm uncorrected



Correction reduces mirror and detector effects by a factor of 5

412 nm corrected

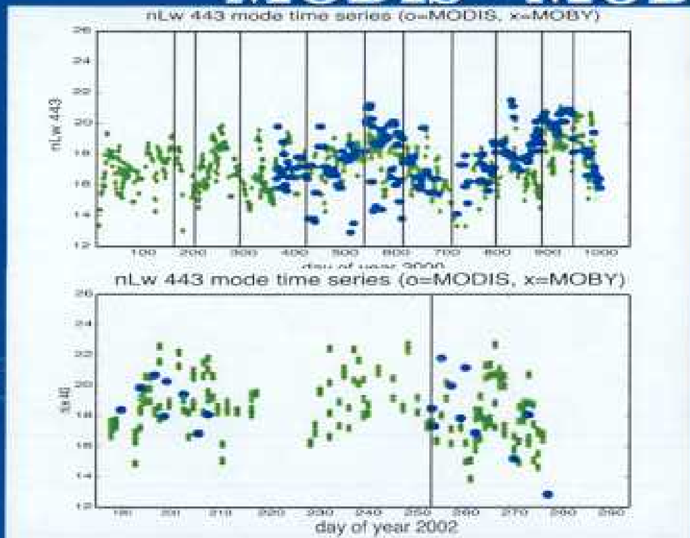


nLw443 Modal & Match up Terra-Aqua MODIS - MOBY Time Series

Terra

Modal nLw443

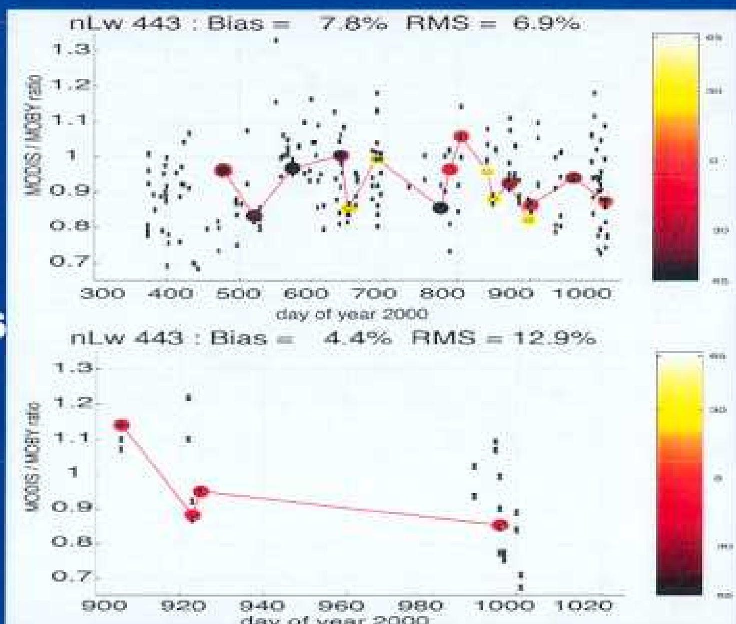
Aqua



Terra

Match-ups nLw443

Aqua



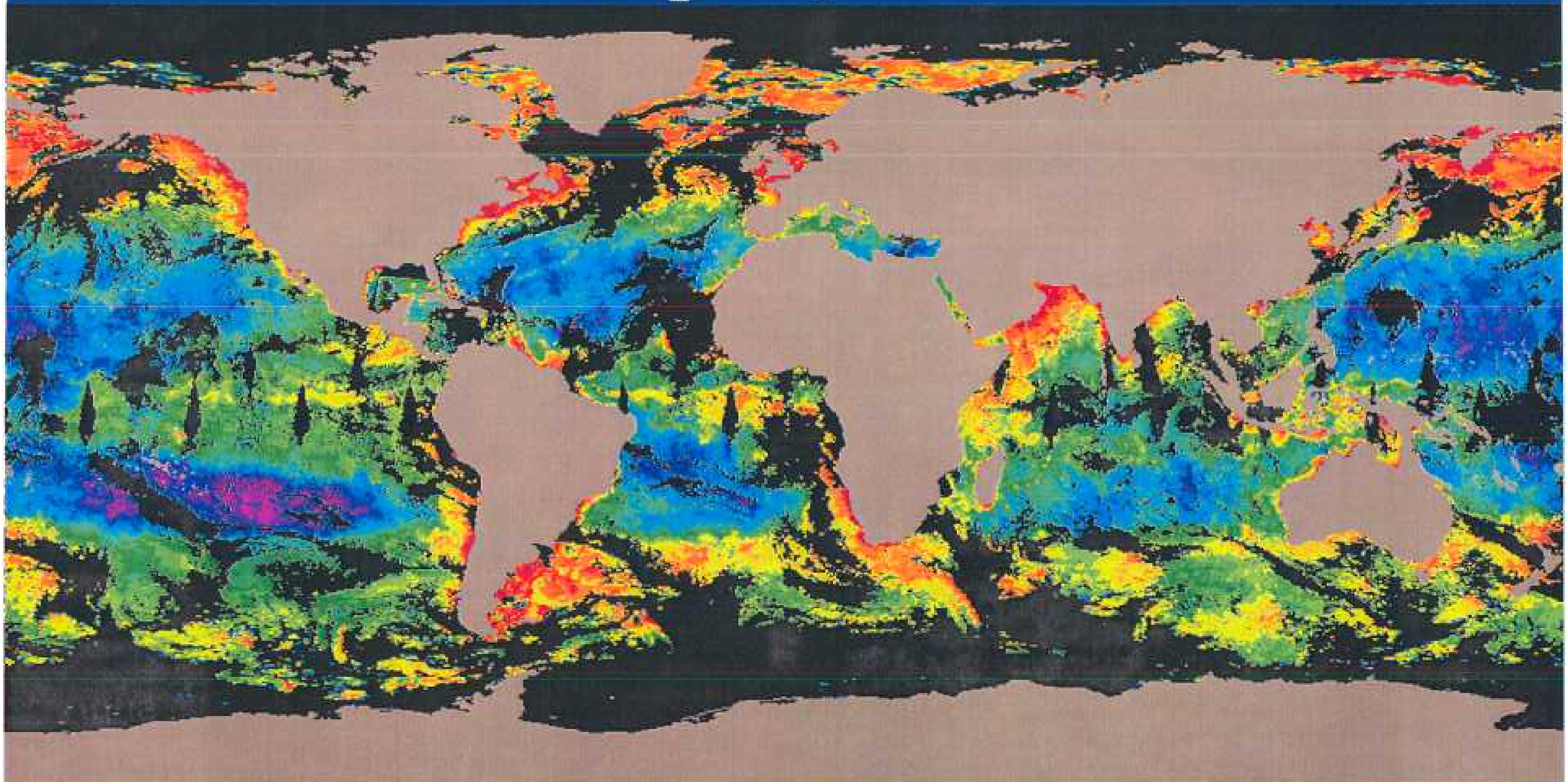
Match up Statistics - MODIS - MOBY residuals by wavelength, final bias adjustment in progress for Version 4 L1b

Wave-length	Terra		Aqua	
	Bias	Std. Dev.	Bias	Std. Dev.
412	0.915	0.115	0.974	0.199
443	0.922	0.069	0.956	0.129
488	0.948	0.051	0.973	0.092
531	0.927	0.103	1.033	0.093
551	0.921	0.105	1.023	0.101

Top Left - Modal Plots of MODIS and MOBY L_w *vs* time used to compute time corrections

Bottom Left - MODIS/MOBY point matchups, used to compute bias corrections

Merged Aqua, Terra Chlor_MODIS Global Chlorophyll Sept 29, 2002

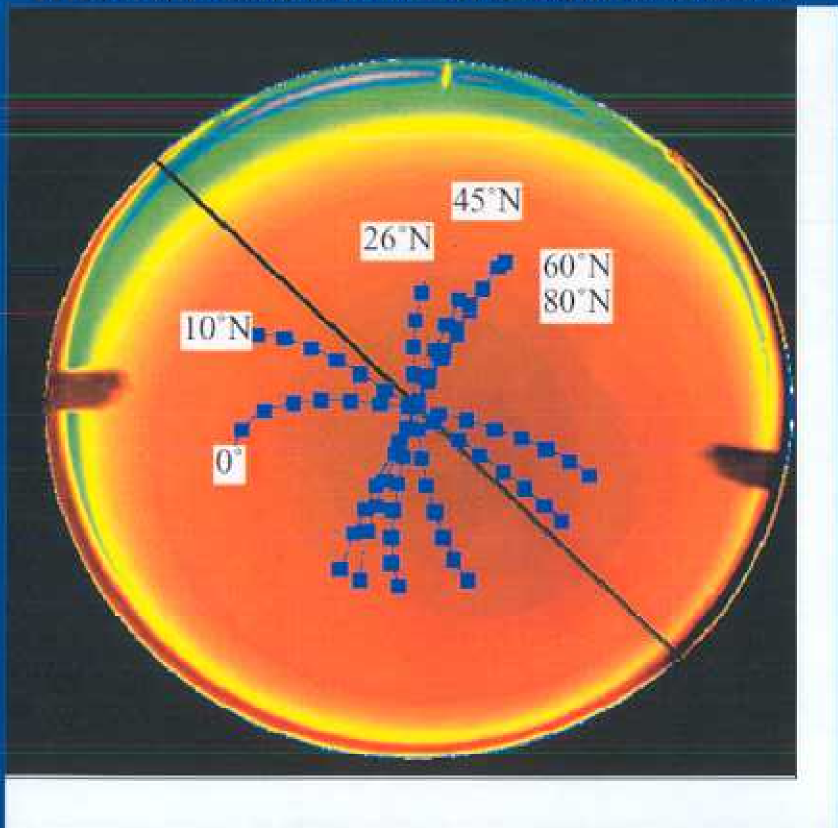


Radiance distribution *vs.* azimuth and solar zenith angles (Ken Voss)

Scan line geometry, variation with Latitude, 0° to 80°N

MODIS

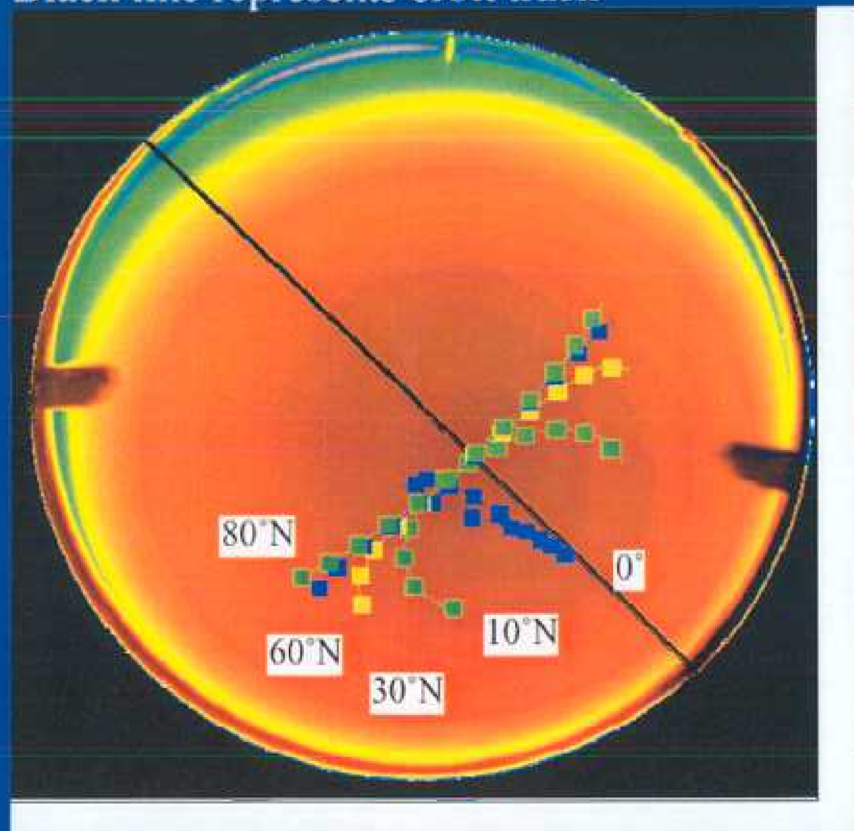
Black intrusions mark orientation of Sun.



Satellite scan changes from near parallel to perpendicular along orbit track

SeaWiFS

Black line represents orbit track

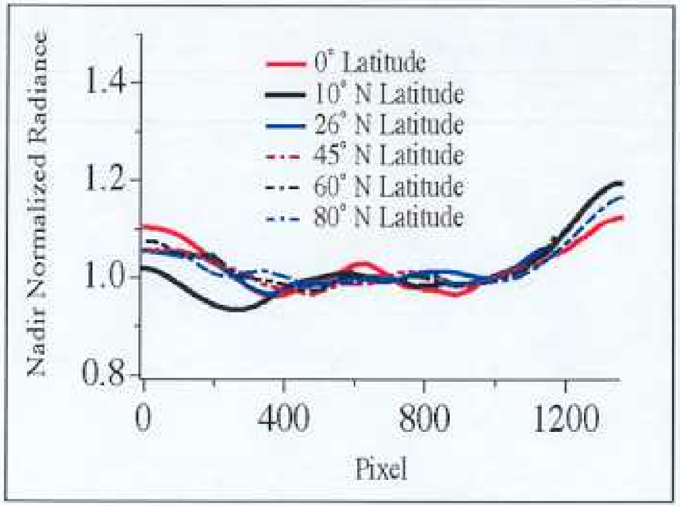


Satellite scan perpendicular to orbit track

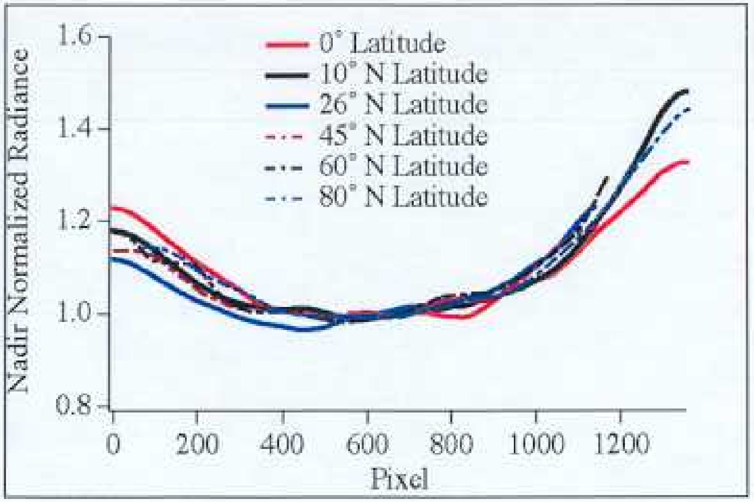
Terra -MODIS Scan Angle Relative To Nadir Lu

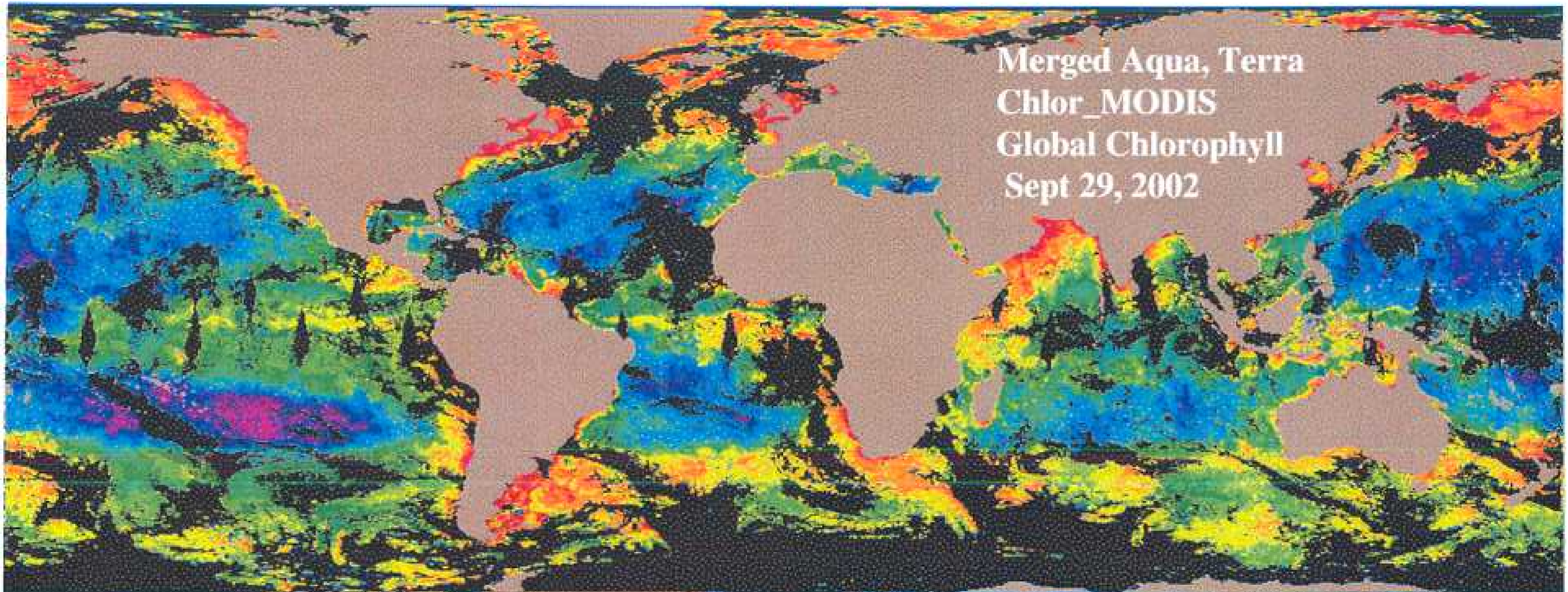
MODIS, 440 nm

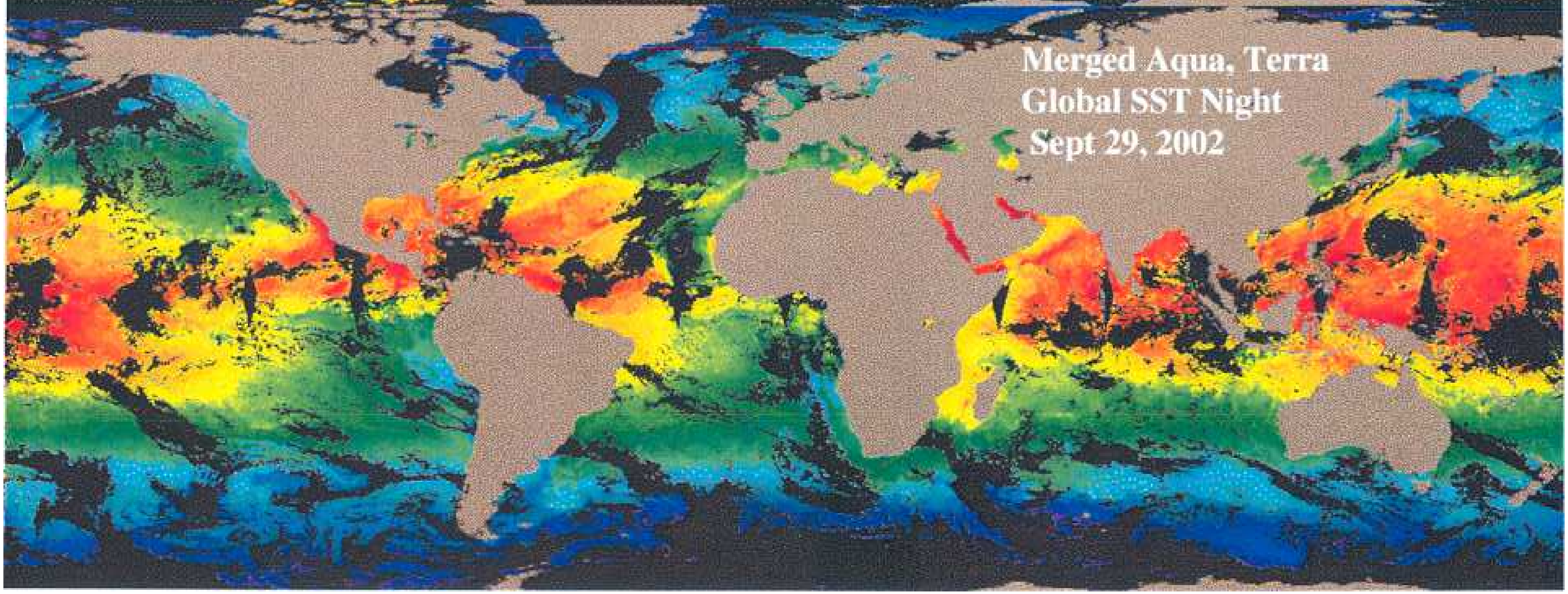
Low Chl (0.3 mg/m)



High Chl (5 mg/m^3)




Merged Aqua, Terra
Chlor_MODIS
Global Chlorophyll
Sept 29, 2002


Merged Aqua, Terra
Global SST Night
Sept 29, 2002

MOBY/MOCE
Five Year + Time-Series
7/20/97 to Present

- NIST Radiometric Scale & Overview
- NIST Stray Light Characterizations
- Sensor Spectral Band Matching
- Ocean Color Sensors Supported
  - Japan's OCTS
  - SeaWiFS
  - MODIS Terra and Aqua
  - Japan's GLI (Fall 2002)

- Primary Reference Standard for Climate Quality Ocean Color Time-Series